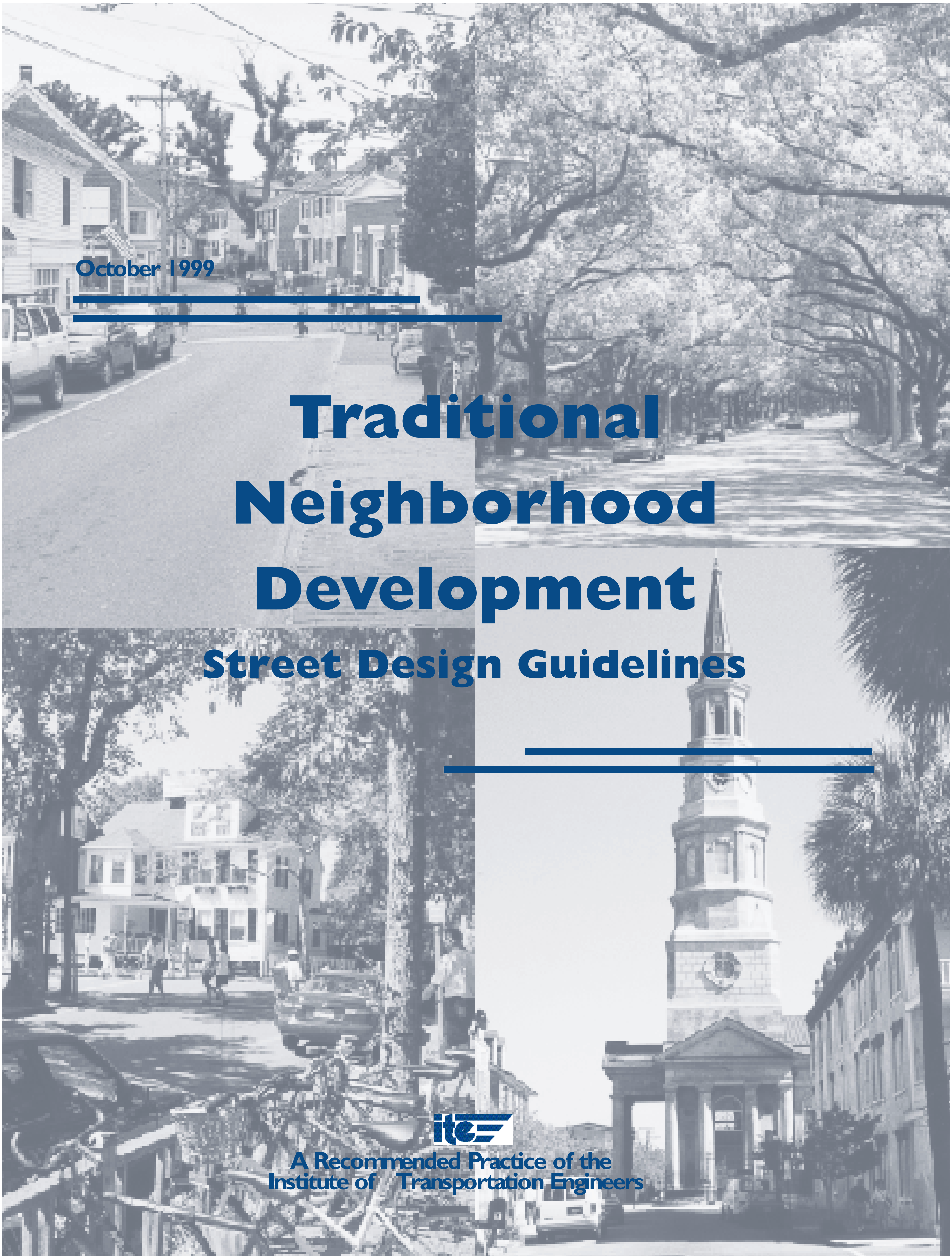

October 1999

Traditional Neighborhood Development

Street Design Guidelines

A Recommended Practice of the Institute of Transportation Engineers

Prepared By: ITE Transportation Planning Council Committee 5P-8

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STANDARD ITE METRIC CONVERSION INSERT

During the service life of this document, use of the metric system in the United States is expected to expand. The following common factors represent the appropriate magnitude of conversion. This is because the quantities given in U.S. Customary units in the text, tables or figures, represent a precision level that in practice typically does not exceed two significant figures. In making conversions, it is important to not falsely imply a greater accuracy in the product than existed in the original dimension or quantity. However, certain applications such as surveying, structures, curve offset calculations, and so forth, may require great precision. Conversions for such purposes are given in parentheses.

Length
1 inch = 25 mm (millimeters—25.4)
1 inch = 2.5 cm (centimeters—2.54)
1 foot = 0.3 m (meters—0.3048)
1 yard = 0.91 m (0.914)
1 mile = 1.6 km (kilometers—1.61)

Volume
1 cubic inch = 16 cm3 (16.39)
1 cubic foot = 0.028 m3 (0.02831)
1 cubic yard = 0.77 m3 (0.7645)
1 quart = 0.95 L (liter—0.9463)
1 gallon = 3.8 L (3.785)

Speed
foot/sec. = 0.3 m/s (0.3048)
miles/hour = 1.6 km/h (1.609)

Temperature
To convert ˚F (Fahrenheit) to ˚C (Celsius), subtract 32 and divide by 1.8.

Area
1 square inch = 6.5 cm2 (6.452)
1 square foot = 0.09 m2 (0.0929)
1 square yard = 0.84 m2 (0.836)
1 acre = 0.4 ha (hectares—0.405)

Mass
1 ounce = 28 gm (gram—28.34)
1 pound = 0.45 kg (kilograms—0.454)
1 ton = 900 kg (907)

Light
1 footcandle = 11 lux (lumens per m2—10.8)
1 footlambert = 3.4 cd/m2 (candelas per m2—3.426)

For other units refer to the American Society of Testing Materials (1916 Race St., Philadelphia, PA 19103). Standard for Metric Practices E 380.

Traditional Neighborhood Development Street Design Guidelines
An ITE Recommended Practice
by ITE Transportation Planning Council Committee 5P-8

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This report, Traditional Neighborhood Development Street Design Guidelines, was approved in September 1999 as an ITE recommended practice. This report supersedes the proposed recommended practice dated June 1997. The comment period on the proposed recommended practice closed on August 15, 1997. Comments on the June 1997 document have been incorporated into the 1999 document. The report includes a discussion of the concepts of traditional neighborhood development (TND), which are also referred to as "the new urbanism," as they relate to the role of streets in TND communities; a discussion of the community design parameters under which the guidelines would apply; presentation of the design principles underlying the guidelines; specific guidance on geometric street design; and an appendix that summarizes some recent findings on the relationship between urban design and travel demand.

These guidelines were developed under the direction of ITE Transportation Planning Council Committee 5P-8 Traffic Engineering for Traditional Neighborhood Developments. Eva Lerner-Lam (M) proposed the formation of an ITE committee on this important topic, and played a crucial role in organizing the effort. Sherry Ryan helped to structure the committee's work by developing an extensive bibliography of related documents. Steve Celniker (M), Owen Curtis (M), William Lieberman (F), John Pavlovitch (M), John Peers (F), Gordon Shaw (M), and A.T. Stoddard (A) all reviewed drafts of the proposed guidelines and made valuable suggestions. Steven Colman (M) assisted in addressing comments.

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The Institute of Transportation Engineers (ITE) is an international educational and scientific association of transportation and traffic engineers and other professionals who are responsible for meeting mobility and safety needs. The Institute facilitates the application of technology and scientific principles to research, planning, functional design, implementation, operation, policy development and management for any mode of transportation by promoting professional development of members, supporting and encouraging education, stimulating research, developing public awareness, and exchanging professional information; and by maintaining a central point of reference and action.

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A. PREFACE

The production of *Traditional Neighborhood Development (TND) Street Design Guidelines* commenced formally in 1992 and was referenced as a goal in ITE's 1994 Informational Report, *Traffic Engineering for Neo-Traditional Neighborhoods.*[1] Since that report, Technical Committee 5P-8 has settled on the simpler "TND" label to address the sort of development described in this publication.

These guidelines have also been prepared to aid the profession with the design and evaluation of a recently emerging, perhaps re-emerging form of development that is not the typical "subdivision" of recent years. Because they address a topic that is new to many designers, some parts of these guidelines may at first seem unusual or perhaps even controversial. Indeed, if applied in the wrong context, these guidelines could prove to be problematic (as, importantly, is also the case for any set of design guidelines). However, these guidelines have been developed to address the particular requirements of certain types of land-use mixes that are most simply described as parts of a town or a neighborhood.

Before presupposing design parameters based on labels or presumed understandings of the intents of these guidelines, it is imperative that prospective users of these guidelines first read all of the design principles and methodologies given; only in this way can the intents of these guidelines be met and proper design and construction occur. TND design is not simply a matter of narrower streets, nor is TND design a simple matter by any measure. The "simple" application of highway standards has often wrought significant change and, in some cases, damage to older and to some newer neighborhoods.

TND design is based on many important principles. These principles and some background information will first be enumerated in these guidelines. These guidelines begin with some key design premises that are different from the design premises associated with other development forms. It is, at the outset, important for practitioners and others to be able to recognize TND development, and thereby recognize where to use these guidelines. To assist with this recognition of TND development, a series of TND principles will be given, along with several of the design rationale concepts so that the particular design principles may be understood and the appropriate design standards can be established.

While labeling is a specific TND principle (see D.11), for sake of simplicity, these guidelines use the inclusive term "street" for linear corridors that mix motor vehicles, pedestrians, cyclists, and transit facilities over wide volumetric ranges (public transit, for example, while always desired is not always present).

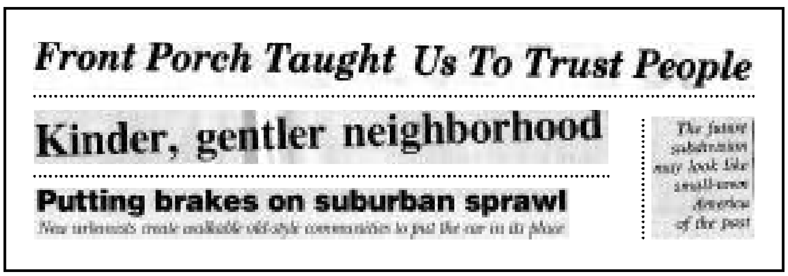
ITE has recommended practices for both TND streets and post-war suburban streets. This publication is not intended to endorse one design technique over the other; however, where a TND street system is proposed, these are the practices that ITE recommends.

B. INTRODUCTION AND CONCEPTS

Street design always involves the design of some of the most important and most used public spaces. This is especially true in the case of TND design, where the designers' perspectives are broadened to include the divergent needs of pedestrians, cyclists, transit, and motor vehicles; the street's relationships to adjacent and future land uses; and where many factors must be compared, considered, and decided to develop the final design solutions. Several of the design principles associated with these competing factors are presented and discussed herein.

Many practitioners will be able to make use of these guidelines. However, due to the broad perspectives involved, many particular design decisions are best made with the assistance of a multidisciplinary design team, always including the suggestions and judgment of a licensed engineer. Critics of conventional development patterns have sometimes attributed many land-use problems or adverse impacts on neighborhoods to traffic and traffic engineers. Conversely, many traffic problems or adverse impacts on traffic flow have been attributed to land uses, land-use planners, or architects. However, rational investigation will usually show that the problems are perhaps more correctly attributed to a lack of communication among the complaining disciplines.

Children and other nondrivers are also needlessly impacted by any environment that is motorist-predominant. When a nonmotorist cannot safely or conveniently travel to a day's events without a vehicle, even simple matters such as children's recreation outside of the home become more rigidly scheduled due to travel coordination needs. This travel coordination places demands on the drivers, who must modify their schedules to transport the nondrivers. The societal impacts of such requirements are beyond the scope of these guidelines, but they are doubtlessly significant. The net effect of a motorist-dependent environment is certainly hobbling to both drivers and nondrivers. TND design allows the possibility of nonmotorist travel and the replacement of some vehicular trips with nonvehicular trips.


Front Porch Taught Us To Trust People

Kinder, gentler neighborhood

Putting brakes on suburban sprawl

New urbanists create walkable old-style communities to put the car in its place

The future subdivision may look like small-town America of the past

Figure 1. Typical, recent articles: *Florida Times-Union*, September 30,1993; *Union Leader*, September 22, 1994 (Erma Bombeck); and *Engineering News Record*, May 9, 1994.

In recent years, engineers, urban planners, and others have either learned, been told, or have come to believe that many, perhaps most, forms of real-estate development and its associated impacts (which have occurred since approximately 1940) have not properly or adequately addressed the needs of such development, or of the regional and global communities. Many news articles relating to this topic have been published (see *Figure 1*). Many designers and policymakers have also recently undertaken a reconsideration of the continued need for the mandated regulatory separation of land uses and types, which logically commenced when the Standard Zoning Enabling Act was put forth in the mid-1920s.

In the 1920s, and for many years before and after that time, many commercial and most industrial uses were insensitive to any environmental concerns and, as a result, were wholly incompatible with residential and residentially related uses of any form. The logical fact that these "dirty" commercial uses were actually incompatible with anyone or anything dependent upon the environment did not occur to most people at first. This historic separation of land uses, first dictated by laws and regulations and later by the creation of the suburbs, has resulted in the current requirement to drive everywhere for one's daily needs; indeed, driving has become an "understood" element of daily life in North America.

While this rethinking of certain design criteria has been occurring, Americans have been changing. In 1980, approximately 11 percent of North Americans were 65 or older, and by the year 2025, this figure is expected to double to more than 22 percent of the population.[2] Proportionally, the elderly suffer more vehicular fatalities than do those aged 25–64, and "the fatality rate of the elderly is, to a large extent, determined by their sociocultural situation in the society and by the overall road safety consciousness of this society."[3] To be more specific, while seniors made up only 13 percent of the population in 1990, they accounted for 23 percent of pedestrian fatalities that same year.[4] While seniors show the ability, for safety reasons, to be adaptive in their driving patterns (such as giving up nighttime driving or driving in bad weather), many believe it is logical to consider a change in development patterns that can help minimize the need for motor vehicles.

Individual users of standards and guidelines are not expected to research the historical origin of the standards they may be using, and they are therefore likely to be unaware of some of the history and the design principles that may be behind a particular standard presently in use. Certain aspects of the principles underlying "conventional" street design criteria contain design premises that are fundamentally opposed to TND design.

As one example, the civil defense committee of the American Association of State Highway Officials (AASHO, the predecessor of AASHTO) required that all street design standards—local and other—include the principles of evacuation before, and cleanup after, a nuclear strike. In another case, the 1940s planning text *Can Our Cities Survive?* included a photograph of a European city ravaged by aerial bombing with the caption "[w]e [planners] cannot ignore the air-raid menace" as part of a full-page reminder of the recent horror of large-scale war, and the need to plan for the probabilities of war. A typical, compact European city was described as "the best target." On the other hand, a more sprawling, one-family "district" was noted as more desirable because "the chances of a hit and its destructive effects have been considerably reduced."[5] Obviously if street design includes, as threshold premises, the necessities of facilitating either mass evacuation under emergency conditions or heavy equipment to access and clean up demolished neighborhoods, then it is unlikely the results will be walkable neighborhoods.

While such design premises may have been appropriate or even laudable in the 1950s, the lingering effects of such concepts are best stricken from both the stated and the unwritten parts of present standards. These guidelines have a distinctly different set of design concepts and principles. However, to think of these guidelines as some form of relaxation or reduction in street design criteria would be a fundamental mistake, although one perhaps easily made without a full understanding of the TND principles. In addition, since the TND concept proposes a series of fundamentally different design concepts not directly addressed or sometimes not even contemplated by most other developmental types, forms, and regulatory criteria, attempting to use existing standards intended for other purposes is usually inappropriate. Rather than proposing a developmental concept that seeks or requires any lessening of design criteria, the TND concept logically requires particular, appropriate design criteria.

C. APPLICABILITY

These guidelines are intended for TND neighborhoods with both attached and free-standing buildings. These neighborhoods also share mixed residential and commercial uses and fairly wide-ranging levels of individual lot density, from about 1 to 40 or more dwelling units (du) to the acre (neighborhoods within a TND typically vary densities within the project, with the overall residential project density in the United States averaging six to ten dwelling units/acre; approximately 25 percent more in Canada). TND lots and buildings are also usually provided access at the rear of the lot by means of an alley. TND neighborhoods are also designed and constructed to maximize nonmotorist mobility for residents and visitors.

Users of these guidelines are reminded that the street design recommendations apply to communities and locations that conform to design features cited previously. Applying these guidelines to communities having the features of "conventional" suburban development such as lack of mixed uses, lower densities, and lack of pedestrian facilities can lead to problems as great as those that result from applying conventional street design guidelines to TND neighborhoods. Users are also reminded that streets in a TND are not intended to carry large volumes of through traffic and that an adequate, separate, system of arterial roadways is necessary to serve higher volumes and long distance travel.

D. TND DESIGN PRINCIPLES

D.1. Specificity

One of the most basic and pervasive aspects of TND street design is that this form of design is very specific for the particular street at hand. This principle requires more work on the part of designers who must review each street in a neighborhood and use the best information available to design that particular street, sometimes for separate sections of a street. It is for this reason that all of the design principles must be understood and set forth, to be used in conjunction with engineering judgment. A result of this design specificity is that each street and alley is designed and labeled for its particular purpose(s). (See *Figure 2.*)

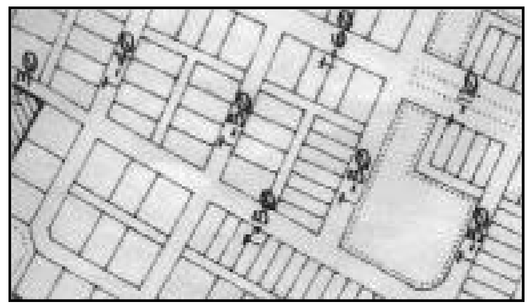


Figure 2. Street mix.

D.2. Concept of "Lanes" and Shared Street Space

A principle that is central to the design and sizing of streets in a TND is that where streets are not striped for separate lanes of travel, designers must not automatically think of separate "lanes" of traffic or parking in an additive sense (with respect to lane dimensions). An example of this concept often can be found on relatively narrow residential streets, either at low densities or when rear alley access is provided to the buildings. On these streets, with intermittent on-street parking, the street's width may occasionally require one driver to slow down or pull over to let an oncoming vehicle pass before proceeding, particularly if one of the vehicles is a truck or other large vehicle. The keys here are the words "occasionally" requiring drivers to pull over or stop and "intermittent" on-street parking that allows such pulling over. There are many such streets in the United States, and they are typically well liked by residents.[6] From the designer's perspective, where volumes are low and large vehicles are few, one may actually only need a single, relatively clear or through lane. This same concept applies to all streets in a TND: street width, which primarily defines the vehicular space and which must be crossed by pedestrians, must not be larger than is actually needed.

D.3. Scale

Scale is a threshold design parameter that determines the size and amounts of several important design elements and is of paramount importance in a TND. The principle of design scale in a TND neighborhood is that of the pedestrian; in another manner of speaking, human scale predominates.

Describing what is of a "human scale" (see *Figure 3*) is perhaps first best described by noting that which is not. A highway billboard beside a 55 mph highway is a good example of vehicular scale. To attract attention, such a sign must be very large (typically 15′ x 40′ or more), with lettering large enough to be noticed and read by a motorist passing by at 81 feet per second (55 mph). A pedestrian, on the other hand, typically walks at only 3.5 to 4 feet per second, and small details are more noticed than are large ones. A pedestrian walking next to a billboard likely would not feel comfortable next to that billboard—simply attempting to get the perspective needed to even read it would be very difficult.

What this matter of scale equates to for the designers of streets is a new focus. Instead of being primarily concerned with and designing for vehicles and then "accommodating" pedestrians and others, TND designers must consider the sometimes competing needs and impacts of each design parameter on all of the users of the street. Given successful design in accordance with these principles, there should be a larger than usual number of pedestrians in the makeup of the users of the street. However, the pedestrians must obviously share the street with cyclists, transit vehicles, passenger cars, trucks, and emergency vehicles. All of these users and occupants of the street require many competing design factors to be considered.

D.4. Bicycles

Bicycles are perhaps the most energy efficient means of travel. On average they are five times more efficient than walking and, of course, they do not consume fossil fuels. Bicycle travel should be encouraged in TND projects. Designers must be aware of the features needed to accommodate bicycles. The on-street parking typical in a TND may present conflicts, and bike lanes adjacent to parked cars must be designed with care to avoid conflicts between the bicycles and opening car doors.

It is also important to note that at the speeds associated with TND streets, there is often less need for separate bicycle lanes or facilities. Bicycles are an appropriate and expected element of the street.

D.5. Street Space

The TND street begins at the front of a vertical element, such as a building (or fence) on one side of a street, and runs to the front of a building on the other side of the street. Some planners call this building-to-building space around a street the "streetscape" (see *Figures 3* and *4*). Where the land is not yet developed, a TND street designer must know with some certainty the scale of the buildings; the existing and projected vehicular, bicycle, and pedestrian volumes; and the general form(s) of development that are expected to occur on the undeveloped land. In the same vein, the evolution of improved land in a TND should be known with some specificity. Where the scale and general forms of types of development are known, it is more practical to accurately predict and design for the needs of the vehicular and nonvehicular users of each TND street.

Figure 3. Human scale.

D.6. Connectivity

TND streets are interconnected. This principle is central to TND design. Cul-de-sacs and other dead-end streets are not a part of a TND. Except in areas where extreme topographic or wetland conditions preclude connection, streets are connected (where extreme conditions preclude street connections, continuous nonvehicular connections should still be attempted). The need for street connection is twofold:

(1) for vehicles, TND streets function in an interdependent manner that is better-served by connected streets; and (2) connected streets provide continuous and more comprehensible routes that serve to enhance the benefits of nonvehicular travel.

Where it is difficult to provide full through streets, there are design alternatives to cul-de-sacs. One option is the "close" (pronounced with a "z"). The close is a simple "U"-shaped street with a natural or landscaped interior of the "U." Keys to making an appropriate close are to have a one-way loop and the middle area generally between 50 and 150 feet in width.

Figure 4. Simple streetscape.

D.7. Through Traffic and TND Street Networks

Most TND streets are designed to minimize through traffic. This concept is often accomplished by using three-leg or "tee" intersections (see *Figure 5*), street widths, occasionally one-way routings, and general street network design. Designers can manipulate the travel characteristics and mitigate the impacts of travel through the design of the elements of the streetscape and in selecting the locations of land uses. As examples, the type and location of on-street parking, the locations of land uses that are attractors of diverted link or other "outside" trips, and the locations of nonvehicular centers and destinations can all be useful tools to minimize or discourage through traffic.

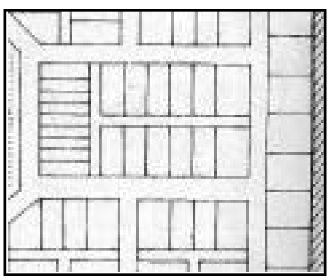


Figure 5. Tee-intersections.

D.8. TND Street Capacity

The concept of minimizing through traffic ties in with another TND principle: more of the capacity of a TND street network is utilized than is typically the case in conventional "dendritic" street networks. In conventional networks, traffic is expected to begin at local (often cul-de-sac) streets, then flow to collector and then to arterial streets, ultimately into the more regional systems. This type of network collects and focuses traffic, often leaving few choices to drivers. Nondrivers are also conventionally excluded from large portions of the network, either by regulation or by the vehicular orientation of the designed and constructed environment itself. In a TND network with no dead-end streets there are always multiple ways to connect any two locations. With multiple routes presented to motorists and nonmotorists, more options are made possible. Vehicular trips can be diffused or reduced by drivers choosing alternative routes, or by choosing to travel by means other than the automobile.[7]

This TND principle should not, however, be taken as a mandate to eliminate larger streets or to eliminate all hierarchy of streets in a TND. Private vehicular travel is still a part of travel today, and at the edges of TND neighborhoods larger vehicular corridors may be found. Indeed, one of the challenges of TND design is to allow the diffusive flow of traffic without creating short-cuts that encourage cut-through traffic.

D.9. Pedestrian Networks

TND streets are shared with pedestrians. While a network of streets is important for vehicular efficiency, networked, safe and convenient connections are of paramount importance to the pedestrian. For these reasons, all lots and sites have pedestrian connections. TND streets usually have sidewalks that are five or more feet in width along both sides of the street, except at the lowest densities or at the edge of the neighborhood.

Figure 6. Offstreet walkway.

In addition to sidewalks, pedestrian networks can be formed with connections across wetlands and slopes that may not be crossed by streets without difficulty. In the center of neighborhoods, pedestrian networks may also be formed by additional walks between buildings—but not at the expense of maintaining the continuity of the pedestrian network adjacent to the streets (see *Figure 6*).

D.10. Pedestrian Street Crossings and Curb Return Radii

To allow convenient street crossings by pedestrians at street intersections, the curb return radius must be very carefully selected. The principle is to carefully consider the traffic mix expected, particularly the size and frequency of vehicles, the size of single unit (SU) and larger trucks, and the percentage of right-hand turns those larger vehicles will make and then to balance the needs of those vehicles with the numbers of pedestrians. If the proportion of large vehicles is few, then it is usually acceptable to allow these vehicles to swing across the centerline of the street, meaning either the street the vehicle is turning from or the street it is turning into. When this occurs, if a vehicle is approaching along the street the larger vehicle is turning into, either the larger vehicle or the approaching vehicle will have to stop to let the other complete its turn, or the turning vehicle has to wait to let the oncoming vehicle pass by. This concept is in accord with principle D.2., “Concept of ‘Lanes’ and Shared Street Space.” Larger curb return radii more easily accommodate the right-turning vehicles, but at the expense of increasing pedestrian crossing distance, this effect is detailed in the section on geometric design that follows.

D.11. Labels and Street Nomenclature

Due to cross-sectional characteristics, design assumptions and sometimes the regulatory requirements associated with them, labels such as "local street,” "collector," and "arterial" are usually avoided in TND design (except outside or at the edge of the TND neighborhood). While some TND streets may, singly or in groups, provide the same ultimate service to motor vehicles, it is recommended that street labeling become more project specific and related to the street at hand. For example, it is recommended that labels follow the convention of a two-letter "designator" hyphenated with the right-of-way width and, if striped for on-street parking, a "P" suffix is added. For example a street with a 50 feet wide right-of-way becomes "ST-50;" that same street striped for on-street parking becomes "ST-50P.” Recommended labels for various street types are as follows:

▼ A *boulevard* is a larger multilane and generally urban corridor with a central, planted median; its designator is "BV.”

- An *avenue* is a connector that may be multilaned and runs through a TND, terminating its axis at a civic building or monument (see "Vista Terminations"); its designator is "AV."
- A *street* typically allows two-way vehicular travel, is of closed-section (curb and gutter) design, typically has sidewalks on both sides, does not have a central median or "refuge" area, and is the most common corridor in a TND; its designator is "ST."
- A *road* provides access to primarily residential neighborhoods of lower densities (one to three dwellings per acre), may be of open or closed drainage section, and only seldom has striped parking on street; its designator is "RD."
- A *drive* is found at the edge between a developed, sometimes urban area and a natural area such as a river or woodland; one side of a drive may be detailed with curbing, gutters, sidewalks and striped parking, while the other side may be detailed as a more rural condition, depending on location and the designer's intent; its designator is "DR."
- An *alley* is found to the rear of lots, has no sidewalks or setbacks, is designed as the service route for the lots it abuts, and is typically constructed with inverted crowns and center drainage, but may be constructed otherwise where lower density residential lots only are serviced; its designator is "AL."

Figure 7. Vista termination.

D.12. Vista Terminations

Designers of a TND must be cognizant of the development occurring outside the rights-of-way of the streets being designed. Important sites can be created for civic buildings, monuments, gathering points, and overlooks. Such sites, when occupied by an important building or other memorable structure "anchor" the end of the street for motorists and pedestrians alike, and they can serve to enhance a particular neighborhood's character or sense of community. Considering the relative ease with which such sites may be created, designers should always consider this concept and should seek to learn what civic buildings may be needed for a particular area when designing a TND neighborhood (even if such building plans are years in the future).

Vista terminations can also serve to slow through traffic, since simple tee intersections can make a fine vista termination location.[8]

D.13. Emergency Vehicles

Emergency vehicles must be afforded access throughout a TND neighborhood to every parcel and structure. However, designers must be careful to consider several factors when designing emergency access. Unlike dendritic street networks, there will always be at least two routes of access to any point in a TND. In addition to access from the street, lots in a TND will also usually have access from a rear alley. Emergency vehicles have the legal right-of-way in emergency situations, and they have the legal right to use all of the traveled portion of the street. Also, while not generally recommended, in unusual circumstances special emergency equipment may be needed to service a TND neighborhood.

In short, designers should be cognizant that emergency vehicles have greater access options and rights than other vehicles, and the effects of decisions concerning turning radii and paths must be made with a full understanding of the implications of such decisions on the other users of the street.

D.14. Utilities

As with emergency vehicles, but somewhat more simply addressed, the location of utilities is important in a TND neighborhood and along TND streets. Where space is available, utility outlets, service entrances, transformers, and the like should be centrally clustered in a neat and orderly fashion. They should be located to the rear of buildings or screened from public view wherever permitted by building and electrical codes. Similarly, where overhead utilities and poles are used, these should be located to the rear of lots in alleys, where alleys are provided.

Where overhead utilities exist or will be located in the street to the front of lots, the competing needs of the vehicles and the nonvehicular users of the street will be evaluated in accordance with the principles of these guidelines. In the event of conflict not otherwise addressed by these principles, the simple convenience of a utility provider shall not take precedence over the needs of the vehicular or the nonvehicular users, or the aesthetics of the street.

D.15. Locations of Highways and Other Large Vehicular Corridors

Arterial highways, major roads, and other streets with projected peak hourly flows of 500 vehicles, or average daily traffic volumes of more than 15,000 vehicles are all too large to penetrate a TND neighborhood. Such streets may be thought of as rivers to pedestrians (in an effective sense) and the other nonmotorists: these streets can be crossed but usually only with extraordinary measures. Pedestrians confronted with one of these streets will quickly realize that they are out of their element, and they will likely not return except by vehicle.

For these reasons, larger streets must be located at the edge of TND neighborhoods or in areas between TND neighborhoods.

D.16. Neighborhood Size

While urban design is not a direct part of these guidelines, a few elementary TND neighborhood design principles are necessary, due to such considerations as where to locate larger streets and how to recognize actual TND projects from those merely labeled as such.

TND neighborhoods are sized in walkable increments, with an approximate five-minute walking radius from the neighborhood center. Since people walk at average speeds of somewhat less than four feet per second, a guideline then becomes a neighborhood radius of approximately one-quarter mile and a neighborhood size range of at least 40 acres, up to a range of 85 to 125 acres. While exceptions may be made due to topographic or other unusual conditions, neighborhoods larger than these sizes become too large to walk and, therefore, do not comport with TND design principles simply by their size.

TND neighborhoods have mixed commercial and residential uses throughout, but each neighborhood's center will have neighborhood gathering points such as a post office, transit stop and, depending on density, a convenience store or other more intense commercial uses. As TND neighborhoods are assembled, they can provide patronage for larger-serving uses, such as supermarkets that are often supported by two to four TND neighborhoods.

Most commercial uses have residential units located on upper floors in TND projects. These upper-floor residential units are often, but not exclusively, affordable units. Two of the urban design principles of TND projects are to avoid areas of exclusive uses or exclusive types of buildings. Land uses and building types and sizes are mixed together with some commonalties, such as pedestrian scale and orientation. Exclusions are limited to truly noxious uses and proposals that are out of scale.

These guidelines do not apply to conventional Planned Unit Developments. Planned Unit Developments mix uses, but they assemble those uses in an otherwise conventional manner that is predominantly vehicular oriented.

D.17. Eye Contact and Street Safety

Societal factors aside, the safest streets include a high degree of eye contact among pedestrians, drivers, and cyclists.[9] Designers of TND neighborhoods should strive to create this condition: if the users of the street establish eye contact, then greater opportunities for awareness have been established and, thereby, the opportunity for a safer street has also in part been established.

Figure 8. Trees forming space.

D.18. Street Trees

Trees are perhaps one of the very few elements of a street, along with well-designed buildings, that can be large and yet still effectively be of human scale. In addition to their naturalization of the street, trees can serve to create a frame around a street, and such "outdoor rooms" are recognized as being very conducive to enhancing the nonmotorist environment (see *Figure 8*).

Where climate and soil conditions permit, trees will generally line the streets in a TND. In areas with few commercial uses, trees are usually located within planting strips six or more feet in width and, in areas with higher commercial densities, trees are located in tree wells located in sidewalks that are usually approximately ten feet wide.

Figure 9. On-street parking.

D.19. On-Street Parking

Most streets in a TND allow on-street parking. On-street parking is known to slow passing vehicular traffic, and the parked vehicles serve to establish a buffer between the moving vehicles and pedestrians.

Parallel parking is the recommended method for on-street parking, but other on-street parking methods, including diagonal and head-in, may be appropriate under certain circumstances, especially including the renovation or adaptation of older neighborhoods (see *Figures 9 and 13*). Wherever on-street parking is located, additional conflicts among the users of the streets are introduced and need to be considered by the TND designers.

D.20. Resolution of Conflicts

Whenever a designer or policymaker associated with a TND determines that an irreconcilable conflict exists among vehicular and nonvehicular users of a TND street space, that conflict should be resolved in favor of the nonvehicular users, unless the public safety will truly be jeopardized by the decision. In resolving such conflicts, part of the decision-making process must include consideration of the design goal of maximizing the mobility of residents and visitors by modes other than in private vehicles. This decision-making process must also include the presumption of higher numbers of pedestrians and the other nonvehicular users of the street.

D.21. Review of TND Proposal

While there are actually few absolutes in the real world, for reasons sometimes not apparent but in any case not relevant to these guidelines, many existing regulations, policies, and policymakers have unfortunately developed “absolutes,” “minimums” and, more rarely, “maximums.” Part of the design of TND streets often involves the investigation and determinations of which of these matters may actually be preferences, desires, or matters of convenience, and which are actually design mandates.

Designers proposing a TND project must be careful to educate those parties involved with reviewing the particular TND proposal as to the design goals, principles, and other differences associated with the TND concepts before the proposal is submitted. At a minimum, it is imperative that the reviewing authorities understand the design premise of promoting nonmotorist travel in all forms.

If such threshold information is not provided and an open discourse is not established, initial levels of resistance and “posturing” may be established that are later difficult to gracefully overcome. Prudent and reasonable designers cannot expect prudent and reasonable responses from the reviewers of a TND project, unless those reviewers are well-informed. TND proponents must bear in mind that most reviewers work within systems of regulations, policies, and practices that are long-entrenched in responding to wholly different patterns of development.

As an example of this type of situation, the fire chief of a large western city, when first presented with a TND proposal, commented during discussions concerning the geometrics desired for the fire equipment of that city that his vehicles "do not back up"—even after a fire or other emergency had ceased.[10] This obviously would have presented a nearly insurmountable design problem and, ultimately, with many discussions and further meetings, this chief admitted that his initial reaction was misplaced. He ultimately settled on a more reasonable position, after a better understanding of the project was achieved.

As a point of information, early fire trucks used what was otherwise reverse gear in conventional trucks to power the pumps; simply, early fire trucks could not back up. This early design problem resulted in turning requirements that necessarily accounted for the need to maneuver fire trucks without any backing maneuvers. Modern fire apparatus can back up to accomplish turns, and this sort of maneuvering is expected under certain conditions, especially when a fire or other emergency has ceased, and the equipment is leaving the neighborhood.

The design team of a TND should always prepare the best hard data available, such as specific dimensions, vehicle-turning radii, projected traffic mixes (particularly including projected volumes of trucks or other large or specialty vehicles), and other matters that can be quantified. As the discretionary design decisions are made, the rationale supporting each decision should be documented in accordance with the available hard data and the principles of these guidelines. By this method, the process of the resolution of inevitable conflicts will be available for later review, if need be, and for presentation to decision-making authorities, which is usually necessary.

E. SAFETY

E.1. General Concepts

In any design situation, no topic is more important than human safety. However, the broad topic of safety can also become an intentional or unintentional blockade to the consideration of ideas and elements of street design that might, if given fair consideration, effectively work together to create a relatively safe condition. “Safety” is a relative term, and its accommodation in street design situations requires the consideration of many, sometimes competing elements.

While most experienced designers already recognize the importance of human safety, it is important to note that it is impossible to design any real-world situation that is entirely safe for all possible purposes. An unsafe condition can be created by a wide variety of means that are beyond the control of designers; those most affecting street design being human error, vehicle failure, and roadway conditions (AASHTO defines these influences as the “human,” “vehicle,” and “highway” elements of safety).[11]

In considering the human element, safety can sometimes be achieved or enhanced by either creating a design that is itself forgiving of human error, or by educating human users so that the users of the particular design are educated as to how to handle foreseeable problems. For example, highway designers have sometimes attempted to create designs that are themselves forgiving of human error and mechanical failure—witness the concept of the “forgiving roadside.” However, even this relatively simple highway concept becomes problematic when applied to slower-speed streets and other mixed motorist and nonmotorist environments.[12] The design of slower-speed TND streets, as opposed to highways, presents new sets of criteria for the designers to consider, evaluate, and ultimately make design decisions about. While there is little that is mathematically complex concerning TND street design, such design nevertheless requires balanced consideration of the complex mix of elements that are foreseeably found on a TND street, and which often present competing needs (for example, delivery trucks and recreational pedestrians).

In street design, the standards that should be applied and questions that should be asked by designers during the design process include the following safety-related matters:

- What actions may reasonably be expected of motorists and nonmotorists along the particular street?
- Given a particular and foreseeable but infrequent problem (such as a speeding vehicle) what are the ramifications on other users of the street if the particular problem is specially accounted for by the design?
- When balancing conflicting matters, the frequency of conflict between the two or more competing elements and the resultant frequency of difficulties that will be experienced should be documented and carefully considered.
- What are the physical consequences of a particular design element or decision?
- If fairly in doubt, favor the nonmotorist and accommodate the motorist.

The first question raises the concerns of what a reasonable and informed designer might predict as likelihoods along a particular street. This question, however, is also inextricably linked with the second concept and the balancing test given in the third.[13]

As is noted by AASHTO, "The number of accidents increases with an increase in the number of decisions required by the driver."[14] A corollary to this truism is that the actual and potential effects of each driver-decision become more significant as the speed of the particular motor vehicle increases.

As an example of one element of the design process, it is certainly possible and, depending on the particular situation, perhaps reasonably foreseeable that a motor vehicle may speed along a particular street. If the street and its adjacent land uses are otherwise designed to create high numbers of nonmotorists mixed with motorists traveling at typical speeds of 20 mph, then to accommodate an errant driver at, for example, (40 mph) may have consequences that become significant to the other, more frequent users of this street.

When a fair question exists concerning a particular design detail, favoring the nonmotorist will usually result in the correct decision because

- ▼ if a fair question exists, there is rationale to support a decision for the motorist or the nonmotorist;
- ▼ motorists have the benefit (from a safety perspective) of traveling in a device designed to enclose, protect, and support the human(s) inside;
- ▼ an inconvenienced driver will seldom result in a modal shift, but an inconvenienced nonmotorist will often become a motorist to avoid inconvenience.

Finally, designers should be aware that, when designing a public street for a governmental agency, the legal doctrine of sovereign immunity may apply. This doctrine provides liability exemption for governmental bodies working in the public interest. Provided that the goals of promoting and therefore, expecting a much larger number of non-motorists is a part of the planning process, then reasonable designs intended to promote non-motorist travel as are encouraged in these guidelines will be shielded from judgment. There are very few provisions under U.S. law to preclude a legal action, but the doctrine of sovereign immunity may guide the result. Where governmental agencies are not involved, sovereign immunity may not apply. In such instances, designers should follow the reasonable and appropriate design practices as are outlined in these guidelines, documenting their intents and conflict resolution as they proceed.

E.2. Speed, Reaction Times and Stopping of Moving Vehicles

To begin to quantify the ramifications of speed of a motor vehicle, the driver's perception/reaction times and the resulting changes in stopping distances required for various speeds are all relevant (see *Table 1*).

The topic of driver reaction time involves the perception of the particular need for an action, a decision as to what action to take, and then the implementation of that decision. If a driver needs to look away from the road to see a possible problem or to consider multiple, confusing events, then the likelihood of driver error increases, as do the overall perception and reaction times. Choosing to stop is a simple action and one that has been the subject of several studies. For purposes of design, an overall driver perception/reaction time of 2.5 seconds is considered appropriate, and this is reflected in the table and discussion that follows.[15]

As can be seen in *Table 1*, the total required stopping distance increases by a factor of somewhat more than three when the speed doubles from 20 to 40 miles per hour (which is usually the assumed design condition on wet pavement).[16] However, the breakdown of what occurs from the instant a driver encounters the need to stop to the moment when the vehicle actually stops is illuminating and of particular interest for TND street design.

Speed (mph)	Friction	Perception	Reaction	Stop	Total	Change (ft) from 20 mph	Change (%) from 20 mph
10	0.44	15'	22'	8'	44'	-62'	-59%
15	0.42	22'	33'	18'	73'	-34'	-32%
20	0.40	29'	44'	33'	107'	0'	0%
25	0.38	37'	55'	55'	146'	40'	+37%
30	0.35	44'	66'	86'	196'	89'	+83%
35	0.34	51'	77'	120'	248'	142'	+133%
40	0.32	59'	88'	167'	313'	207'	+194%

Given: Reaction 1.5 sec. Perception 1.0 sec.

Table 1. Speed, reaction times, and required distances.

First it should be noted that, due to driver reaction time, a vehicle traveling 20 mph will travel approximately 73 feet before it even begins to slow down from the effects of a braking action. At 40 mph, this reaction distance doubles to 147 feet of vehicle travel before the vehicle begins to slow from braking. Therefore, for any given speed, it must be remembered that there is a critical distance immediately in front of a vehicle where a collision may occur even before the vehicle has begun to slow down. This critical distance is charted in *Figure 10.*

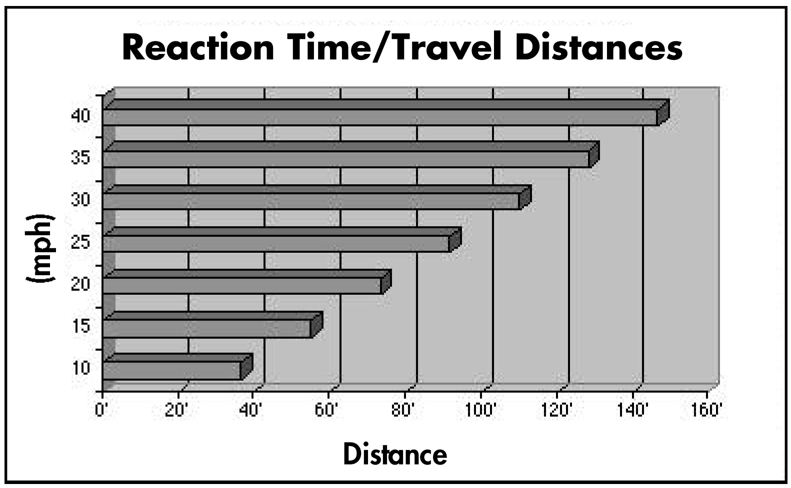


Figure 10. Reaction distances for speeds 10 to 40 mph.

More significantly, the actual distance traveled by the vehicle as it comes to a stop after the brakes have been applied is five times more at 40 mph than at 20 mph (increasing from 33 to 167 feet); this is also a function of physics not related to driver skill or awareness. Even if an increase of only ten miles per hour is evaluated (from 20 to 30 mph), 2.5 times the braking distance alone is required to stop (33 to 86 feet). Clearly, the distances traveled by a moving vehicle after a decision to stop has been made are of significance to designers (see *Figure 11*).

E.3. Design Speed and Actual Travel Speeds

In comparison with most other recent developments, relatively low actual travel speeds for motor vehicles in a TND are critical to the TND concept; these reduced travel speeds must be accomplished by design. The design criteria of TND streets where properly selected will serve to predetermine and facilitate these slower, actual vehicular speeds through the selection of design criteria, such as pavement widths, proximity and types of adjacent land uses where on-street parking is allowed and may be striped, and all other criteria of street design.

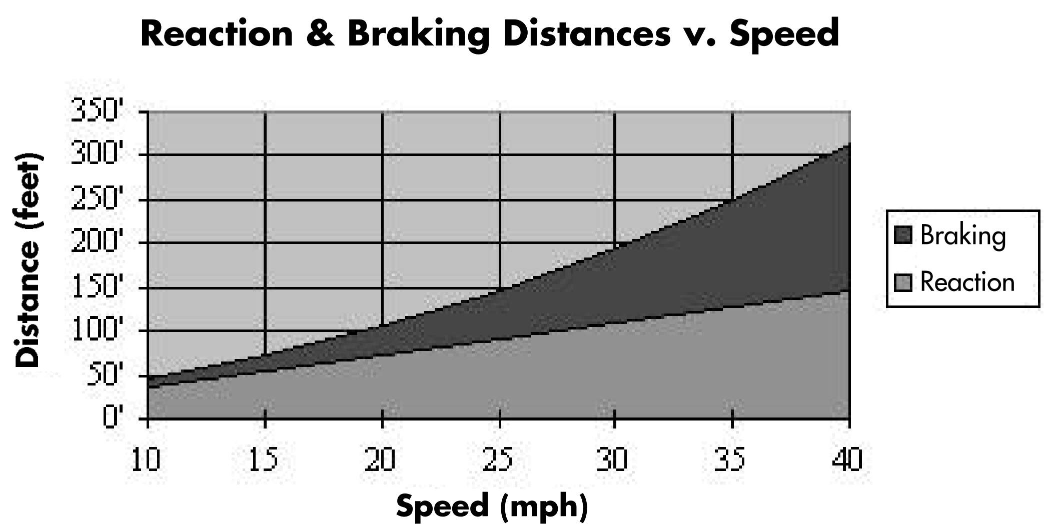


Figure 11. Reaction and braking distances for speeds 10 to 40 mph (level grade).

The desired upper limit of actual motor vehicle speeds on TND streets is approximately 20 mph (29.3 ft/sec). This speed allows the creation of the safest streets for a TND or other pedestrian enhanced neighborhood. Because a vehicle's kinetic energy, sound, and the difficulty of seeing the driver all increase dramatically with vehicular speed, speeds at and below 20 mph are also the speeds that are generally the most aesthetically pleasing for pedestrians and cyclists. Pedestrian perceptions are also very important. It has been noted that it is actually the "feeling of being unsafe, the experience of a certain threat emanating from traffic" that ends up dedicating streets to primarily vehicular travel and discouraging pedestrian traffic.[17]

It is generally understood that pedestrians are more of a design consideration in "residential districts" and, therefore, pedestrians must become more of the design-parameter process. As pedestrians are designed to be part of the increased nonmotorist presence in TND projects, pedestrian perceptions become more important and some "residential district" criteria becomes relevant to TND design.

Many planning texts contain references to appropriate vehicular speeds so that nearby nonmotorists are not too adversely impacted by the moving vehicles. Some recently published guides and adopted standards also reflect the desirability of lower design and travel speeds for similar reasons. It is noteworthy that the speed cited as preferred is quite often given to be approximately 20 mph or 30 kilometers per hour (approximately 18.6 mph) where metric measure is more prevalent.[18]

There are many more planning and design references that are not specific but relate such qualitative terms as "safety" and "comfort." When actual examples are shown or referenced, the actual travel speeds of moving vehicles on a particularly favored street is at or below 20 mph. In similar fashion, traffic calming texts also try to establish various levels of vehicular speeds, and one of the commonly important thresholds of speed cited is, again, the 20 mph/30 Kmh threshold.[19]

E.4. Regulatory Issues

Several jurisdictions in the United States have lower thresholds of speed limits that are either 25 mph or 30 mph; often the lowest limits are also allowed only in school zones.

While the regulatory history of this practice may be grounded in attempts to eliminate so-called speed traps, in the 1950s and later, the effect is the same whatever the source: these "lower" limits are too high for many TND streets, because of the safety and perception reasons cited previously. Practitioners may need to work with regulators and/or legislators to establish the proper framework within which to create a new TND neighborhood.

This is an important point, because if the local laws or requirements mandate that the constructed street be posted at 25 or 30 mph, then that street should be appropriately designed for that speed. To do so will likely eliminate the creation of a true TND street, but not to do so may create difficult conditions for drivers and would also likely invite liability in the event of an accident. New legislation may be required in some jurisdictions to enable the lower design and travel speeds necessary in a TND project.

Where streets are posted with a 25 or 30 mph speed limit, conventional design practice indicates designing the street with a 5 mph higher speed. Since the underlying design premises include absolute comfort and very little lateral forces on a driver or occupants at design speed, it is actually physically comfortable (absent other factors on the street) to drive a street designed for 30 mph at 40 mph or more; some newer automobiles that isolate drivers from road forces and conditions exacerbate this condition even more. As is detailed in the next section, the lower vehicular speeds are necessary in a TND project, and the ramifications of even apparently slightly higher speeds should be understood before they are selected or required.

Some other national bodies have recently created model regulations that seek to establish lower design speeds for all forms of subdivisions. For example, the American Society of Civil Engineers (ASCE) Subdivision and Site Plan Standards Committee has developed some recommended subdivision and site plan standards in cooperation with the U.S. Department of Housing and Urban Development. These standards establish maximum design speeds of 20 and 25 miles per hour for "access" and "sub-collector" streets, respectively. It is hoped that as these matters receive more focus and consideration, other agencies will acknowledge the logic in the concept of these lower speeds.[20]

The best solution to this problem is usually to seek the addition of a new set of requirements for TND streets, much as is represented by these guidelines. Other, potentially less involved, possibilities may be to establish a special "pilot" or "model" zone inclusive of the area(s) in mind. Since most TND projects include schools, how school zone boundaries are defined under the local laws should be closely examined, and the limits of that zone should be as inclusive as possible around the TND neighborhood. If the TND includes historic property, some flexibility may be found as many goals of historic preservation are parallel with the geometrics of lower design speeds.

E.5. Dynamics of Vehicular Speeds and Pedestrian Injuries

A further examination of the dynamics, especially the kinetic energy associated with a moving vehicle and the potential dangers associated with that energy, may begin to explain the uniformity of citations and the importance of seeking vehicular speeds of 20 mph and below.

The total kinetic energy associated with a moving vehicle is related to the square of the velocity of that vehicle. A vehicle's kinetic energy can also be subjectively perceived by most pedestrians by the noise associated with the moving vehicle. Not surprisingly, the level of pedestrian injury that is likely if a pedestrian is struck by a moving vehicle also increases with the square of an impacting vehicle's velocity.[21] This relationship is explained in *Figure 12.*

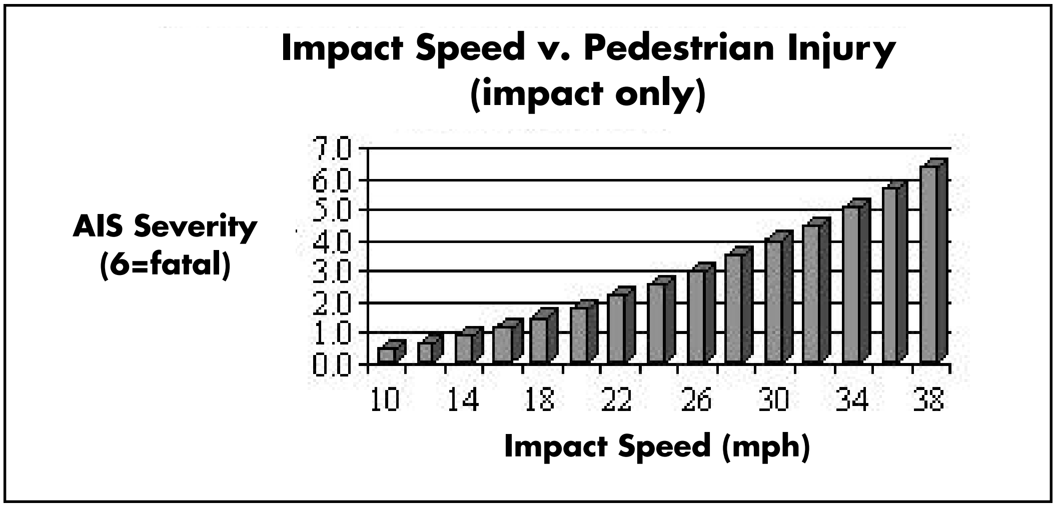


Figure 12. Pedestrian injury indexes for speeds 10 to 38 mph (AIS = abbreviated injury scale)

Without becoming too detailed or too graphic, in the event of a pedestrian being struck by a motor vehicle there is also a secondary impact that occurs when the pedestrian strikes the ground.[22] With some further analysis, it can be determined that the risk of very serious injury to a pedestrian increases dramatically as the speed of an impacting vehicle exceeds 20 mph. This increase in risk is due to the effects of both the initial and the secondary impacts.

The probability of fatal injury becomes likely from initial impact alone as vehicular speeds reach and exceed approximately 35 mph. Rudolph Limpert, in his text *Motor Vehicle Accident Reconstruction and Cause Analysis*, states that "analysis of car/pedestrian accident statistics have shown that the probability of [the pedestrian] receiving fatal injuries is 3.5 percent at 15 mph, 37 percent at 31 mph, and 83 percent at 44 mph."[23]

This data and analysis also show that pedestrians' perceptions and the planning and other texts' references may be grounded in kinetic realities because of the substantial differences associated with injuries for vehicular speeds above 20 mph. Other research has also shown that pedestrians are usually not seriously injured when hit by a car moving at a speed of less than 20 mph (30 km/h) at the time of impact. Note that "if impact speeds are between 20 and 35 mph (30 and 55 km/h), injuries are usually serious, while at or above 35 mph (55 km/h) they usually endanger life or are fatal."[24]

In closing this section on safety and its relationship to vehicular speeds in a TND, designers should seek to establish vehicular speeds below the levels where pedestrian fatalities become likely when pedestrian accidents occur. For safety reasons alone, designers must be careful to consider the particular mix of motorists and nonmotorists and to design for the entire mix in accord with the principles stated. If safety is served in this fashion, then aesthetics and comfort will logically follow.

F. GEOMETRIC DESIGN

F.1. General Concepts

One goal of designers of TND streets is congruent with the goal of designers seeking to calm traffic on streets: to create an environment where drivers will realize that driving too fast or too aggressively is inappropriate, anti-social and, perhaps most effectively, uncomfortable. With the appropriate design methods, drivers will more automatically choose lower target speeds and less aggressive behaviors desired by the designers. In this desired sort of self-enforcing environment, both motorists and nonmotorists will feel as though they are more equivalent occupants of each particular TND street. This sense of equivalency should be a design goal.

The accommodation of large vehicles will be discussed in more detail, but it should be noted that certain larger vehicles, including transit and emergency vehicles and other infrequent vehicles, may need to be specially scheduled or be given special rights-of-way so that they have the necessary access where needed. Otherwise, the street or street element under consideration may be improperly designed for the automobile and the nonmotorists.

This section of the guidelines will serve as an additional illustration of the application of the preceding principles and information into the particular elements of TND street design. It is, again, important that practitioners keep in mind the principles stated previously and the examples given while using these design guidelines. The principles and the context of each example are particularly important and relevant where discretionary decisions are to be made for specific locations and situations.

If designers begin to design for the specific facilitation of only one user of a street, the design focus has likely become too narrow. Designers need to be cautious not to tread on this slippery slope of narrow focus, because it can easily result in a substantial degradation of the quality or safety of the street environment for other users of the street. This probability exists for designers if the nonmotorists become the sole focus of design consideration (the exceptions are, for example, single-focus needs such as wheelchair ramps and truck loading docks).

TND design should be recognized as a multidisciplinary process that typically involves architects, planners, regulatory officials, environmental specialists, and engineers. Public agency suggestions are also important, especially that of local and regional transit agencies when available. Many transit agencies have shown leadership in urban design issues and can provide valuable ideas about the design process. This concept applies equally to other agencies that may have important design impacts on the physical form of the proposed TND.

F.2. Elements of the Street

There are, generally speaking, only a dozen or so elements that make up the design of a street, but the assembly of those elements and the determination of the sizes and locations of those elements are of lasting importance. While implementing future changes to a street usually is essentially built-in when the street is first constructed, reconstructing streets is costly and should be avoided, unless a particular need is shown (such as a pilot or test street that may be reconstructed to a different section at a later date if needed).

At the most elemental level, the platting of streets determines the division of land ownership patterns on the large scale; from this large-scale division, the smaller divisions of subdivisions and individual lots evolve. While the smaller divisions will often times change, sometimes dramatically, over the years the larger divisions of land effected by the platting of streets will seldom change and, for this reason alone, the size, alignment, and locations of streets are of particular importance to the practitioner.[25]

Certain threshold design elements that make up a street must be individually considered in order to design that particular street. Some of these elements are "given" based on the particulars that may be occurring outside the rights-of-way of the street (such as the types and densities of adjacent land development), while other elements are selected by the street's designers, such as whether and how on-street parking will be allowed. These elements of the street are as follows:

- the volume and mix of nonvehicular and vehicular traffic that will be (or is) located on the street;
- the width of the traveled surface of the street;
- whether on-street parking will be (or is) allowed, and in what form and frequency;
- the type of drainage (either a curbed street with closed drainage or an uncurbed street with open drainage);
- the size and location of sidewalks adjacent to the street;
- whether or not planting strips will be located adjacent to the street;
- what speeds vehicles will travel along the street as designed or redesigned;
- whether adjacent properties will be serviced directly from the street, or if alleys are provided or will be provided;
- what types of utilities will be located along the street, both above and below ground;
- what the adjacent building setbacks may be with respect to the street.

F.2.1. Particular Vehicular Street Mix

The mix and volume of the traffic that will be located along a particular street is one of the most important criteria to first be considered in sizing the elements of that street. On streets with relatively low volumes of vehicular traffic and small numbers of trucks and other large motor vehicles moving in the target range of approximately 15–20 mph, TND streets are places shared almost equally among pedestrians of many ages, cyclists, and automobiles. At these lower volumes, mid-block crossings by pedestrians are not uncommon, and such crossings are usually accommodated in a safe manner—they are expected.

As vehicular volumes and speeds increase, several design factors come into play: the need to separately stripe each traffic lane becomes more advisable; pedestrians become more exclusively restricted to sidewalks; pedestrian crossings of the street become more restricted to designated crosswalk locations; cyclists are also given separate bike lanes; and other design guidelines become more appropriate.

The design dimensions of the various users of the street are relevant for practitioners and *Table 2* is provided for convenient reference.

The dimensions in *Table 2* are not provided as substitutions for the design values given from AASHTO, but rather as reminders to designers that the design values have some additional dimensional tolerance built-in, and this additional tolerance can become important where, as here, street width differences of only a few feet are very important.

			AASHTO Design Dimensions		Comparative Dimensions		
Vehicle	Symbol	Height	Width	Length	Width	Length	
Pass	P	4.3'	7'	17.5'	6.0'	16.0'	Full-size car
SU truck	SU	13.5'	9'	30'	7.0'	21.8'	UPS truck
SU bus	BUS	13.5'	9'	40'	8.0′	40′	School bus

Table 2. Vehicle Dimensions

While TND street networks do not follow the same rigid functional classification of conventional neighborhoods with local, collector, arterial, and other streets, TND streets are hierarchical to facilitate necessary movements. Larger streets, both in terms of size and vehicular volumes, are found around and outside TND neighborhoods, while smaller streets with lower vehicular volumes filter motorists and nonmotorists in and through neighborhoods.

Based on traffic volumes, Appleyard categorized San Francisco's streets into "light," "medium," "heavy," and "very heavy," with respective daily volume ranges as shown in *Table 3*.[26]

Category (Appleyard)	Lower Limit of Traffic (ADT)	Upper Limit of Traffic (ADT)
Light	0	2,000
Medium	2,000	10,000
Heavy	10,000	20,000
Very Heavy	"over 20,000"	

Table 3. Street categorizations (Appleyard)

This categorization was for a different purpose than TND design, and most of the streets studied were essentially conventional in terms of their motorist and nonmotorist behavior, but the Appleyard work is valuable for the reference it provides on a resident's tolerance of traffic volumes, noise, and speeds.

In TND design, the daily and hourly peak volumes of traffic are important considerations, as are the anticipated volumes of larger vehicles and the particular times of day each type of vehicle will need access to the particular street. *Table 4* is provided for TND street categorizations. Since there are few rigid formulaic methods for designing TND streets, this categorization is provided so that practitioners will have a common means of classifying TND streets according to vehicular volumes.

Type	ADT	Peak Hour	Typical Percentage of Large Vehicles
I	<1,500	<100	up to 5%
II	1,500	100–200	up to 5%
III	2,500	200–300	5% to 10%
IV	5,000	300–400	5% to 10%
V	7,500	400–500	10%

Table 4. TND street categories (by traffic volume).

F.2.2. On-Street Parking

On-street parking can be of several different types, including parallel, diagonal, and head-in. Diagonal parking can be problematic from the pedestrian's perspective because of the sawtooth-type encroachments that the fronts of parked vehicles can make into the sidewalk area. Where driver behavior is well-ordered (admittedly unusual in most locales today), diagonal parking may not encroach as is shown in *Figure 13*.

Figure 13. Unusually "polite" diagonal parking.

Head-in parking on the street is relatively efficient and is often preferred by merchants, because of the greater yield of spaces per foot of street. However, in comparison to the amount of street width required for striped parallel parking, head-in parking must be carefully evaluated before implementing, because it requires an additional 11 or 12 feet of street width (extra space must be provided on each side of the street and for the required backing movements). Additional street width directly affects pedestrian crossing times, and that section of these guidelines should also be reviewed before the street width is increased. An additional consideration about where head-in parking should be provided is the transition to a narrower section, where the head-in parking stops or transitions to another element of the street.

On-street parking can be problematic under certain conditions. One prevalent concern is children darting out from between parked cars and into the path of an oncoming vehicle. This is a valid concern, and all such risks cannot be eliminated. Yet on a properly designed TND street the combination of slower moving vehicles, the greater awareness of all persons in and near the street, and especially the expectation among drivers that there are more nonmotorists in a TND all act to create a safer condition. On other streets that are essentially vehicular-dominated and speeds are often 35 mph and above, the dangers of possible dart-out accidents are significant indeed.

On-street parking is usually problematic to cyclists, but it is less so where good levels of awareness exist among cyclists, other nonmotorists, and motorists. Designers need to be aware of the problems associated with parked vehicles and cyclists, such as swinging doors and backing movements. They must to try to develop a means to accommodate both, as bicycling and parked vehicles are both important elements.

On-street parking along one or more sides of the street, which is usually parallel parking, is the normal TND street condition. Diagonal parking is usually more problematic for cyclists than parallel parking, because of backing movements. On-street parking serves to both slow the adjacent vehicular traffic and to provide a buffer between the nonmotorist and the motorist. The beneficial aspects of on-street parking are also recognized: "[o]n-street auto parking is permitted and provided for along many of the best streets, far more than where there is [no on-street parking]...."[27]

F.2.3. TND Street Width

The width of a particular street seems to be a simple topic, but this is actually a complicated topic that requires considerable thought and attention by designers. Indeed, few design topics appear as simple as TND street width, but have as much lasting significance. All of the principles and concepts contained in these guidelines are especially relevant for this topic.

Traffic engineering for conventional, vehicular-dominated development accepts as a fundamentally paired premise that vehicles should travel safely and efficiently. The efficiency component of this coupling means, in part, that vehicles should travel the streets either without interruption or with interruption only at designed traffic control devices, such as traffic signals and STOP signs. It is sometimes believed by designers that any other stop or interruption to a driver is directly equated to a reduction in safety and efficiency. This approach to street design does not comport with the principles of TND design and the need for lower overall vehicular speeds. The overall function, comfort, safety, and aesthetics of a street is more important than its vehicular efficiency alone in a TND. In a TND the fundamental premise is that nonvehicular travel is to be afforded every practical advantage, so long as safety is not adversely affected.

The data clearly show that where nonmotorist travel is to be encouraged, and therefore the numbers of nonmotorists are expected to be higher than is the case elsewhere, then safety considerations mandate the consideration of means and methods to slow the motor vehicles and thereby better balance the street for all of its users, motorist and nonmotorist alike.

Designers should consider that which is reasonably foreseeable, certainly not that which is possible, in matters of TND street design. This standard will show that the most frequent and, therefore, likely users along TND streets are motorists (in automobiles) and nonmotorists of all forms. Each of these predominant users must be considered fairly. This will mean that to design to facilitate (as opposed to providing means and measures to accommodate) an infrequent visitor to a particular street, may be wrong more often than not for the more frequent users of that street.

For example, facilitating large, infrequent trucks would necessitate establishing street turning radii and other dimensions much larger than those needed for automobiles. Consequently, the additional street surface provided for those trucks would encourage faster travel speeds by the more frequent automobiles. As noted previously, however, faster automobile speeds do not comport with the safety needs along TND streets, and the faster automobiles serve to further reduce the likelihood of more nonmotorists.

Transportation facilities are also graded qualitatively by their levels of service (LOS), which are directly related to capacity and lack of unscheduled interruption. New designs and improvements seek to achieve the highest practical levels of service, where an LOS of "A," represents "free flow," so that the "freedom to select desired speeds and to maneuver within the traffic stream is extremely high."[28] Perhaps paradoxically, given the freedom afforded to drivers on streets with an LOS of A, this LOS is also described as providing an "excellent...general level of comfort" to "the motorist, passenger, or pedestrian."[29] While pedestrian volumes can also be graded as to their levels of service (which is what is likely intended by the pedestrian reference quoted), pedestrians are typically anything but comfortable on streets designed for high levels of service for vehicles, except at the lowest volumes of traffic.

Designers will often find examples of older neighborhoods sought out by residents as preferred places to live. Many of these neighborhoods exhibit street sizes and networks that are quite unlike most subdivisions designed to current criteria. Within these older neighborhoods the levels of service on the streets and at intersections may be found from "D" to "E" or even "F." These levels of service would not seem to encourage new residents, but in many cases the quality of traffic flow along the street does not adversely affect residents' desires to live along these older streets. TND proponents will note that this sort of acceptance of a neighborhood is, in part, because traffic may be slowed and inconvenienced due to more difficult older street widths and networks.

Examples of these older streets include (1) many residential streets in Seattle, Washington, that accommodate two-way travel and two-sided, on-street parking within a 25 feet curb-to-curb dimension; (2) similar two-way streets in primarily residential (three-level townhouses) Georgetown, Washington, D.C. , that are 28 to 32 feet in width; (3) similar 2-way on-street parking streets in San Francisco, California, that are 21 feet in width; (4) Madison, Wisconsin, which has streets 22 feet wide with on-street parking and two lanes of travel; and (5) Portsmouth, New Hampshire, which has two travel lanes, one-way streets with on-street parking and first floor commercial within a 26 to 30 feet curb-to-curb dimension. In Portland, Oregon, other examples exist where "many of the city's older local streets range from 18 to 28 feet wide."[30] While these may seem to be extreme examples of deviations from generally accepted design standards, many of these streets also have spot travel speeds of 10 to 20 mph, effectively slowing traffic from the 25 mph posted speeds typically found on residential streets.[31] Clearly, reducing the width of a street has the effect of reducing vehicular speeds.

These streets also provide examples of locations where vehicles must actually make unscheduled stops in the street, particularly when larger vehicles travel these streets or when opposing vehicles meet on the narrower streets. This sort of occasional vehicular stopping along a street should be considered normal along TND streets; in some cases, such streets are known as queuing streets."[32] AASHTO notes that "the level of user inconvenience occasioned by the lack of two moving lanes is remarkably low in areas where single-family units prevail."

To design for the continuous opportunities for free-flowing vehicles (as is the case with 10 feet wide and greater travel lanes) is to create situations where most of the time passenger cars—far and away the predominant vehicle—will travel at speeds greater than are desirable for nearby pedestrians. This becomes a self-worsening situation of degradation of the pedestrian environment: faster vehicles are noisier and more dangerous to pedestrians; faster vehicles generally mean fewer pedestrians; and fewer pedestrians generally mean even faster vehicles.

Principle D.2. “Concept of ‘Lanes’ and Shared Street Space” is especially relevant to the matter of designing street widths. Where vehicles are allowed to travel and to park, there may not be a need for continuous “lanes” of travel in both directions or of parking along one or both sides of a street. Especially for Types I, II, and III streets, as well as streets where significant nonmotorist-oriented retail is located, queuing and slower-moving vehicles may represent the best design for the street. As soon as the street is perceived as consisting of individual lanes of parked and moving vehicles (as it generally must be for Type V and higher volume streets), then each lane of the street must be allocated its own width. This process, however, will result in a street that is wider than necessary, if the volumes of vehicles are such that the street surface will be shared by parked and moving vehicles.

A TND design team will not find a simple chart or table of how wide TND streets should be under different circumstances, here or elsewhere. As the width of a street increases, the more difficult it is for pedestrians to cross, the easier it is for motorists to traverse at higher speeds, and the more vehicular-dominated the street becomes.

A street should be no wider than the minimum width needed to accommodate the usual vehicular mix that street will serve. Accommodation is explained throughout these guidelines. This simple statement will mean that a particular traveled surface may be as narrow as ten, twelve, or fewer feet (in which case it will probably be labeled as an alley or lane). In other cases, streets may be as broad as 60 or more feet (in which case nonmotorists will need a vegetated boulevard or other relief within the street).

If the principles of design and the balance of these guidelines are read and properly applied, appropriate dimensions will follow as a normal part of the design process for the street under consideration.

F.2.4. Minimum Centerline Radii

Minimum design centerline radii are sometimes difficult to find for design speeds less than 25 miles per hour. Using accepted methods of calculation, *Table 5* shows the criteria for minimum centerline radius for design speeds of 25 mph and less (no superelevation).[33]

Design Speed	Min. Centerline Radius
10 mph	22 feet
15 mph	50 feet
20 mph	89 feet
25 mph	166 feet

Table 5. Minimum centerline radii.

F.2.5. Curb Return Radius

When one curbed street meets another, the curbs at the sides of each street are joined by a curved section of the curb known as the "curb return." With larger curb return radii, turning movements of right-turning vehicles are more easily accommodated, but the length of the crosswalk needed to cross the street for pedestrians at that point is also increased, sometimes dramatically. As the curb return radius increases, the likelihood of automobiles that stop to make a right turn decreases due to larger curb return radii creating essentially “free-right” turning lanes for automobiles (this typically happens with curb return radii at and above 30 feet).

The geometrics of the pedestrian crossing distance are dependent on five variables: sidewalk width, planting or "buffer" width between the sidewalk and the curb, street width, the angle of the intersection, and the curb return radius.

Due to the geometry of 90 degree intersections, larger curb return radii have a lesser impact on street crossing distances where the combination of planting buffer and sidewalk width approach the dimension of the curb return radius; this is because the crossing point is pushed back from the intersection and nearer to the point of tangency of the curb return radius.

Examples of the relationships among curb return radius, planting buffer, and sidewalk width are shown in *Tables 6* and *7* including several examples with and without planting buffers adjacent to the street. Note the near doubling of extra crossing distance between a 15' curb return radius and a 10' curb return radius with no planting strip (in bold in *Table 6*).

Example #	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Sidewalk width	5'	5'	5'	5'	5'	5'	5'	5'	5'	5'
Planting/buffer width (to curb)	0'	0'	0'	0'	0'	0'	0'	0'	0'	0'
Curb return radius	5'	8'	10'	12'	15'	20'	25'	30'	35'	40'
Crossing distance to be added to street width	1.3'	4.4'	**6.8'**	9.3'	**13.4'**	20.6'	28.2'	36.0'	44.0'	52.2'
Pedestrian crossing time to be added to street cross time (seconds)	0.4	1.3	1.9	2.7	3.8	5.9	8.1	10.3	12.6	14.9

Table 6. Effects of curb return radius on pedestrian crossing times and distances (no buffer).

Other examples are shown where a buffer or planting strip has been provided in *Table 7* below:

Example #	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Sidewalk width	6'	6'	6'	8'	8'	8'	10'	10'	10'	10'
Planting/buffer width (to curb)	6'	6'	6'	6'	6'	6'	6'	6'	6'	6'
Curb return radius	15'	25'	30'	15'	25'	30'	15'	25'	30'	35'
Crossing distance to be added to street width	2.5'	11.6'	17.2'	1.7'	10.0'	15.3'	1.1'	8.6'	13.6'	19.0'
Pedestrian crossing time to be added to street cross time (seconds)	0.7	3.3	4.9	0.5	2.9	4.4	0.3	2.5	3.9	5.4

Table 7. Effects of curb return radius on pedestrian crossing times and distances (with buffer).

As noted, the minimum curb return radius primarily affects right turning traffic, and most passenger cars operating at low speeds on streets 18 to 20 feet or more in width are able to make a right turn with a curb return radius of 15 feet without crossing the center of the street. Higher speeds and larger vehicles will typically result in the vehicle crossing the center of the street.

Practitioners will find that for conditions where a turning vehicle crosses the center of the street, whether or not it is striped, some will feel that an encroachment into an oncoming lane may have occurred. This is erroneous because, for most TND streets, infrequent vehicles will usually cross the street center-line when making a right turn; if this does not occur, the street has been improperly designed to facilitate rather than accommodate those infrequent vehicles.

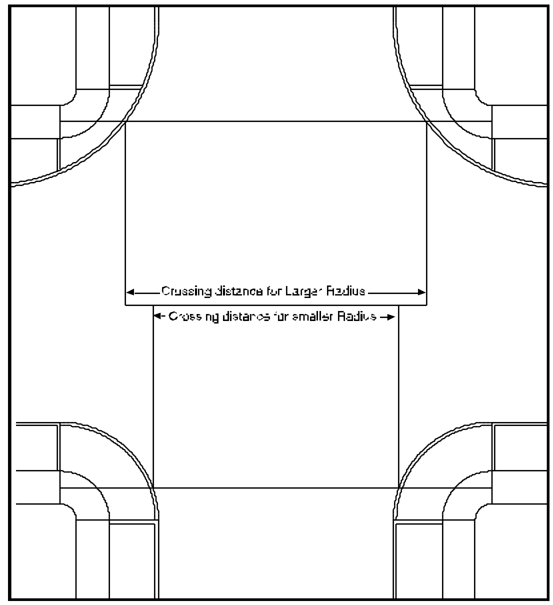


Figure 14. How pedestrian crossing distance is affected by curb return radii.

Even at very low speeds, larger design vehicles (such as WB-40 and WB-50) will encroach sufficiently on an oncoming lane so as to necessitate one of the vehicles (either the one turning or the one approaching) to have to stop and let the other vehicle pass. This is an acceptable design condition where situations of this sort will be an infrequent occurrence.

Curb return radii are one design tool that can be used to slow vehicular speeds and to promote nonmotorists. The zoning, subdivision, and street standards of many cities and other urban areas provide for curb radii of 5 to 30 feet, but most of which are between 10 and 15 feet. Within a specific TND, curb radii should be selected based on reasonably anticipated traffic volumes, traffic types, and the intersection traffic control devices proposed or in place.

Quoting from AASHTO, "...it is often extremely difficult to make adequate provisions for pedestrians. Yet this must be done, because pedestrians are the lifeblood of our urban areas, especially in the downtown and other retail areas. In general, the most successful shopping sections are those that provide the most comfort and pleasure for pedestrians."[34]

F.2.6. Pedestrian Characteristics and Volumes

Some studies have placed less importance on the motorists and have relied on the nonmotorist volumes and densities to help determine the essential qualities of a “great” street. The book *Great Streets* notes several times that there are many immeasurable qualities and attributes of a great street, but that “every fine street...in this book...is one that invites walking.”[35] There can be little disagreement with this standard for fine TND streets—they, too, should invite walking.

Practitioners should bear in mind that when walking is not perceived as safe, convenient, and comfortable, walking is not selected as the mode of travel by those who have a choice.

Sidewalks four feet in width have been a typical standard in much of North America for a number of years. However, and despite the greater cost, a minimum sidewalk width of five feet is recommended where sidewalks are provided, as they better accommodate pedestrians. In four feet of walkway, two pedestrians walking in opposite directions can pass by each other with relative comfort, but two pedestrians cannot walk comfortably together (unless in each others arms) in four feet of walk. In addition, if a pedestrian has any ambulatory difficulties, an additional foot of width makes a significant difference in what is perceived as a comfortable walkway.[36]

Groups of fully ambulatory women crossing a street tend to move at approximately 3.63 feet/second (the rate for fully ambulatory men in groups averages 3.83 feet/second). In consideration of the needs of those who are not fully ambulatory, a design value of 3.5 feet/second is preferred in TND design.

The number of pedestrians found along a street are a consideration in the perceived quality of that street. Generally speaking, the more pedestrians found along a street, the more interesting and pleasurable the street. Jacobs counted pedestrian volumes for the book *Great Streets*, measuring pedestrians in "people per minute per meter" and noting that crowding begins to seem apparent at "perhaps 13" and that "under 2 the walks may seem empty."[37]

Converting the Jacobs data to HCM criteria, this data shows that crowding begins to be apparent at the level of service "E" or "F," which may seem high for most highway designers.[38] Increased pedestrian volumes should be one of the goals of designers and, as with streets, designers should be cautious not to provide too much walkway width and to avoid empty-feeling walkways (generally under two people per minute per meter).[39]

F.2.7. Terrain Classification

Terrain classifications for TND projects are the same as for conventional subdivision streets: level (to 8 percent), rolling (between 8 percent and 15 percent), and hilly (over 15 percent). As with volumetric classifications, these are provided for common nomenclature among practitioners.

F.2.8. Widths of Rights-of-Way

There are no particular requirements for rights-of-way width for TND streets. Typically, in different jurisdictions there are local customs and preferences for certain utilities to be located within rights-of-way of streets, but preferences for other streets should not necessarily be determinants for TND street rights-of-way widths.

Designers should be flexible and open to varying street rights-of-way to include only the traveled surface, to be offcenter with respect to the traveled way, or to other variations that serve to assist with the overall design, use, and maintenance of the street in concert with the other aspects of the street, especially including the adjacent land uses and building types.

Designers will find that planners will seek to align buildings along TND streets to create what are sometimes termed as outdoor rooms. The goal is to create an aesthetically pleasing space for the people in and along a street. Often, straight street alignments and the careful selection of the width of a street's right-of-way can assist with this planning goal without adverse effects to the use of the street.

F.2.9. Bicycles

As noted in the TND principles, bicycles are an increasingly important form of nonmotorist travel. This is true for recreational and utilitarian trips. Therefore, bicycles should be facilitated wherever practical.

In some areas, particularly in northern recreational areas, practitioners may find that seasonal air quality degradation peaks occur during times of the year when weather conditions are also prime for nonmotorist travel. This condition exists along much of the mid-coast region of Maine, for example, where air quality is poorest during the summer months. This sort of situation can be mitigated by encouraging some of the seasonal surge in travel demand to shift to nonmotorist means, and bicycles are prime candidates for some of this shift.

On lower-volume streets, bicycles should be considered a normal part of the mix of travelers on the street. With higher volumes of motorists and bicycles, bicycling routes for less experienced cyclists should be separate from the motorists, but bicycles should be expected and accommodated along all streets. Designers should work to aid the routing of cyclists within and through TND neighborhoods with signage and striping as may be appropriate. The technique of changing the color of the entire bike lane so that it differs from the vehicular space has been found effective at slowing adjacent vehicular speeds in some locations, such as Minnesota, where different colored aggregates were at one time available.[40] Painting entire bike lanes should be avoided unless special paints are used to maintain friction factors where met.

In addition to recreation, bicycles are a serious transportation machine, and bicycle popularity is increasing in the United States. Sales of bicycles have been steady and increasing for some time, and in 1993 U.S. sales were approximately 13 million units, representing the highest level of sales in the prior decade.[41] Of additional significance are the characteristics of cyclists in this country; 56 percent of all cyclists are adults.[42]

The national levels of walking and bicycle use have been quantitatively measured and surveyed, and the data show significant nonmotorist travel. In December 1991, a Harris Poll found that 46 percent of all adult Americans over age 17 had ridden bicycles within the prior year. This same survey also found that 73 percent of American adults had also walked for the purpose of exercise ten or more times during the last mild weather month, and 17 percent of adults had done so 30 or more times.[43] Clearly there is an active, national desire for walking and bicycling facilities, and bicycling is one of the most popular forms of recreational activity. Enhancing opportunities for people to engage in these modes of travel in their neighborhoods will likely stimulate additional travel by nonmotorist means.

Bicycling and walking are viable means of travel for virtually all purposes.[44] Based on the Nationwide Personal Transportation Survey of 1990, the average individual also makes 20 trips per week and 8 percent of those trips, or 1.6 trips, are made by walking or bicycling.[45] To promote and facilitate these nonvehicular forms of travel is completely appropriate for the environment, for any sustainable development proposal, and for a TND design. For additional specific bicycle facility design, reference is made to AASHTO's "Guide for the Development of Bicycle Facilities," 3rd Edition, 1999.

F.2.10. Planting Strips and Street Trees

A planting strip at the curb that is parallel with a street provides some additional buffering to adjacent land uses and to nonmotorists from the vehicles on the street. Local conditions vary, but usually strips of six or more feet work well for trees and other vegetation. Practitioners should be careful not to create larger planting strips that push pedestrian crossing areas back from intersections with larger curb return radii. What may occur in those situations is that more aggressive pedestrians will not use the intended crossing area but will cross in front of motorists attempting to enter the intersection, thereby creating conflicts.

Planting strips are important in northern climates because they also provide long- and short-term snow storage areas. Planting strips also provide areas for stormwater infiltration and can be part of an overall drainage system.

Tree varieties should be selected (and pruned) so that branches and leaf growth are high enough that they do not obstruct a driver's vision of the side of the road or of approaching traffic at intersections.

F.2.11. Stopping Sight Distances

Minimum stopping sight distances should conform to the design speed for the particular street and the stopping distances required for wet pavement conditions, as are shown in *Table 8.* These values already have factors of safety accounted for in the perception/reaction times mentioned previously. These sight distances should be provided by both vertical and horizontal alignment.

Design Speed (mph)	Stopping Sight Distance (feet)
10	44
15	73
20	107
25	146
30	196

Table 8. Stopping sight distances (assuming level grade)

F.2.12. Maximum and Minimum Grades

Minimum grades are usually specified to ensure drainage, and maximum grades are specified for safety concerns. Establishing minimum grades for relatively level sites can create significant grading problems that may require eliminating all existing vegetation on a site. Designers of TND streets should not be restricted by arbitrary minimum street grade requirements if drainage and other concerns are adequately addressed by other means.

Maximum grades are very dependent on local conditions and on the particulars of the section of street under consideration. In areas subject to icing, the weather exposure of the street is relevant, and a north-facing street (a north–south street on the north side of a hill) is more sensitive to icing (in the northern hemisphere) and grade than is a south-facing street. Obviously the volume and mix of traffic along a street are considerations when determining the maximum acceptable grade for the street. High-volume streets with signalized intersections indicate less grade than lower-volume streets. The range of desirable maximum grades falls between 4 to 15 percent). Designers should note that extended grades of more than 5 percent are problematic to cyclists.

Some areas have had success with adding oxidation agents to the finish, wearing, or courses of asphalt mixes in order to mitigate problems with “black ice” and other potentially dangerous street conditions. Again how a particular issue, such as grade, is addressed is properly the subject of a specific design solution and not a categorical classification or requirement.

F.2.13. Alleys

Alleys serve many useful purposes in TND designs. Alleys can assist site designers by allowing narrower lots, and they can enhance safety by eliminating front driveways and the associated backing movements across sidewalks and into the street.

Alleys can also have secondary or reduced-size dwelling units that are either free-standing or are above garages along alleys. Such housing helps to aid safety concerns along alleys by providing "eyes" (in the form of residents) along the alley. This is especially true where senior housing is accordingly situated, and the seniors are available to provide this informal surveillance throughout the day.

Alleys also give streetfront residents one side of their lot that is more public, toward the street, and another that is more neighborhood-oriented along the alley. This allows these residents to have a more ordered and formal front to their properties, while play areas and maintenance areas can be situated along the alleys and shared with neighbors (see *Figure 15*).

Figure 15. Typical TND alleys.

F.2.14. Lighting

The general rule for lighting in a TND project is to prefer more, smaller lights as opposed to fewer, high-intensity lights. This is in keeping with the overall goal of maintaining the elements of a TND street in a human scale, but this also allows for more aesthetic matters, such as allowing people to see the night sky (which is not possible under large lights).

The following have been found to work well along TND streets: lightpoles 8 to 12 feet in height; lighting elements that provide full-spectrum light so that colors at night are realistic; and, in some instances (along alleys, for example), building or fence-mounted lighting that can replace the need for additional street lighting.

F.2.15. Snow Plowing and Removal

Snow removal from streets, sidewalks, and parking areas is a problem wherever snow falls in significant amounts. Generally, those charged with the removal of snow prefer large areas that can be "swept" by trucks with plows so that, as much as possible, the snow can simply be pushed out of the way. This desire flies in the face of many of the TND principles and design methods contained in these guidelines.

Heavy snowfalls should have special management procedures established, based on local conditions and the particulars of a TND project. In some instances, this will mean establishing snow emergency procedures and plans that account for parking circulation requirements while the snow is being removed. Such plans ban parking from opposing sides of the street on alternative nights, so that street space normally used for parking can be used for temporary snow storage while the snow is being removed.

One benefit of TND design is that it results in the creation of more, smaller, and widely dispersed public spaces. TND streets also typically have planting strips or buffer areas along each side. These various public spaces and the planting strips provide opportunities for snow storage space, and designers should consider snow storage as an additional design criteria where appropriate. In many urban environments, heavy snowfall requires the snow to be trucked away. If designed appropriately, TND neighborhoods can help minimize the need to haul away snow in all but the most severe storms.

F.2.16. Trip Generation

Trips are one-way movements by people from one location to another; the most common trip of concern is the vehicular trip. Trip generation models are typically used to predict the numbers of vehicular trips associated with a particular project, and these predictions are used to size the streets within the project and to predict the off-site impacts of a project as well.

Vehicular trip generation models usually, and logically for most recent development, "assume the dominant form of transportation to be the private automobile."[46] In TND projects, where the nonmotorist options are enhanced by design, this may prove to be an invalid, or at least misleading, assumption.

Several recent studies (see, for example, those completed by Mardon; Shriver; Ceuro; and Rutherford) demonstrate that land use and urban design factors do affect travel behavior and can lead to fewer rates of motorized trip generation that would be found on conventional development. The trip not taken in an automobile is also a non-generated trip.

The second and somewhat more documented reduction in trips occurs where there is a reduction in trips made external to a particular project, due to the mix of land uses found internally to the project. Conventional single-use neighborhoods generate the most traffic demands because to travel from one use, such as the home to another, such as a shopping or place of work, requires a vehicular trip. Where mixed uses are provided, even if the mixed uses are otherwise assembled in conventional fashion, external trip reductions of 50 percent have been documented.[47]

Practitioners should be cautious with trip generation projections in and by TND projects, and nonvehicular trips should be carefully considered. If projections are made that do not account for the probabilities of nonvehicular trips, then the resultant trip projections will be higher than are appropriate for the project. This can result in the streets and other vehicular facilities being sized too large in the project and off-site expenditures that may not be appropriate.

As noted previously, sizing the streets too large does not comport with good TND design, and building unneeded offsite improvements is wasteful of resources.

At the same time, providing the mix of uses within the TND project is critical. Absent the incorporation of commercial, retail, and residential uses, the reduction in vehicle trips leaving the TND project will not occur. If the mix of uses is not provided, the application of reduction factors to accepted trip generation rates will lead to inappropriate design of streets connecting the project with regional arterials.

Data continues to be gathered in the area of impacts of urban form on travel behavior, and more research into this area is needed. A report was recently compiled in the state of Oregon that established rules-of-thumb for estimations of reductions in trip generation rates and vehicle miles traveled (VMT). This data is summarized in Appendix A, and one rule-of-thumb predicts a 20 percent reduction in trips for development that is located around a transit center and is generally of TND form.[48] Even greater reductions should be possible with good design and with time for travelers to become familiar with the nonmotorist options and benefits.

F.2.17. Transit

Since the highest levels of patronage for transit stations and stops are often found where such transit may be conveniently walked to, TND design should be inherently compatible with transit. This can indeed be the case for both existing and potential future transit. However, unless transit is considered in the design process, important opportunities may be missed, and actual impediments to good transit may be inadvertently created.

To properly plan for transit, designers should try to have transit access as direct as possible to locations and buildings in each TND. Each transit route should also have direct, safe, secure, and pleasant pedestrian and bicycle access planned as a part of each route.

Ideally for transit, transit services should go directly into the center of each TND neighborhood. As TND neighborhood centers should also have other facilities that will serve to gather pedestrians and other nonmotorists in a safe and pleasant environment, such as postal services, coffee shops, and higher levels of service depending on the size of the neighborhood, transit stops can easily become a part of the design process.

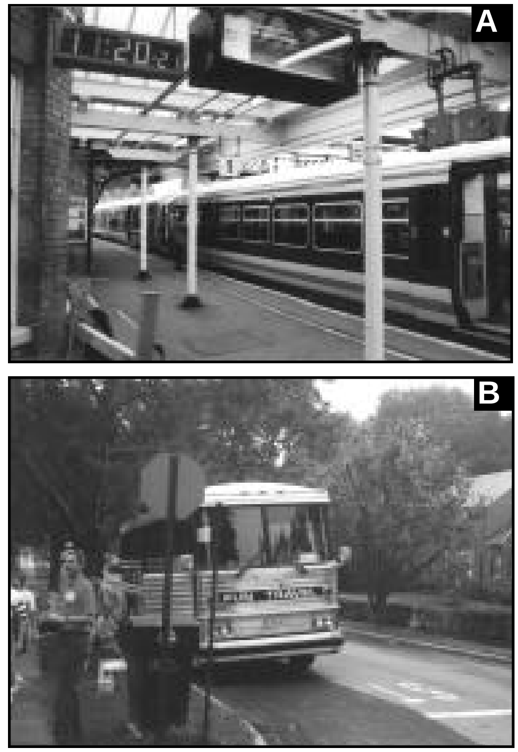


Figure 16. Levels of transit.

G. FINAL CONCEPTS

G.1. Impact of Design and Time Needed

As noted, one theory of TND design is that land-use design and land-use, regulatory criteria can be powerful catalysts for land-use change and, therefore, potential determinants of certain effects, even including behavioral changes, such as less auto usage. As a reverse example, the concept of walking to work seems quite foreign to most people today. It is noted, however, that fully 10 percent of Americans walked to work as recently as 1960 (1960 census data), while in 1990 this figure dropped to 4 percent who chose walking as their primary means of travel to work (1990 census data).[49] Clearly several forces and factors, most of which were designed and built in accordance with then-prevailing guidelines, standards, and policies, acted together from 1960 to 1990 to cause this change in such a fundamental element of daily behavior.

Practitioners and regulators should also bear in mind that the early stages of a TND project will not likely emulate the travel behavior patterns at buildout. Logically, the first residents and workers in a TND will not both live and work in the TND. At the outset, existing employment or existing housing will likely be retained for a time, as will many shopping and other trips. Therefore, the early stages of a TND project should not be considered to represent a model of how that project's residents will behave in a travel sense over time. The early travel results and characteristics should not be projected to buildout.

An already generally accepted design and behavioral modification concept that is not dissimilar to this TND transition period (in part through inconvenience) as is contemplated for TNDs occurs where in-town or CBD parking is restricted and traffic congestion tolerated in order to promote public transit. Over time, however, it seems reasonable to anticipate that more employers and residents may choose the conveniences of the TND, once it exists.

G.2. Appropriate Design

Designers are cautioned to carefully consider all of the aspects of street design discussed herein, but not to compromise TND concepts to ease transition, or for other seemingly well-intentioned purposes that will only serve to create a deviant design form that will not follow either the TND principles or those of conventional vehicular-based design. Any design concept that ultimately proposes such fundamental change as does the TND, before being proved or disproved, necessarily experiences a transitional period within which some individuals, and drivers specifically, may be inconvenienced.

Streets have provided routes of commerce and places for human interactions for centuries. When all of the individual elements are correct, the emotional and functional equivalents of designed resonance seems to occur. The best streets are often widely known as special places for people of mixed ages and backgrounds. The design of streets that are fully functional, in a human sense, involves more than engineers because it also involves more than what happens on the pavement or between the curbs. Some have even said that "[s]orcery and charm, imagination and inspiration" are all required to design the best streets.[50] While sorcery has no part in these guidelines, seeking to create results that may seem functionally equivalent to magic is not out of order and charm, imagination, and inspiration are all good design aspirations.

Design must not be lightly discounted, particularly when dealing with land-development patterns and patterns of mobility. Land-planning patterns, which necessarily determine or direct land ownership, leasing, and construction of facilities, are long-lasting and land-use design direction cannot be fairly evaluated or decided based on the short-term. The next thirty and perhaps fewer years, given the design direction, might achieve fundamental changes in daily behavior patterns similar to those witnessed over the past thirty or so years.

Designers should remember that streets are multifunctional, and they should aspire to create streets to be enjoyed by all. They should strive to create the best of today's most prevalent public spaces.

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H. APPENDIX A: TRANSPORTATION IMPACT FACTORS

Table A-1. Transportation Impact Factors – Development with No Transit Service

Transportation Impact Factor	Development Pattern	Density/ Intensity	Pedestrian/ Bicycle Facilities	Street Characteristics	Sources
1% Vehicle Trip Reduction	Development located adjacent to bicycle lanes	No specified requirements.	Bicycle lanes connect residential areas with commercial and employment uses. Provide safe and secure bicycle parking.	Destinations to be traveled by bicycle should be five miles or less. Reasonably level terrain. Streets or streets with speed limits of 35 mph or less.	ITE, 1993
2.5% Vehicle Trip Reduction	Mixed-use commercial and light industrial development that includes residential units. At least 20% of floor area devoted to residential uses.	For commercial and light industrial development, a FAR of a minimum 0.75 per gross acre.	Direct, safe connections between residences and commercial/industrial uses. Preferable: safe and secure bicycle parking provided at commercial and light industrial uses.	Commercial uses located with minimal setbacks.	ITE, 1993 LACMTA, 1995
5% Vehicle Trip Reduction	Residential oriented mixed use. At least 15% of floor area devoted to commercial uses oriented towards use by residents.	Minimum residential density of 12 du/acre	Direct, safe connections between residences and commercial/industrial uses.	Commercial uses located with minimal setbacks. Commercial retail and semi-retail uses.	LACMTA, 1995
7% Vehicle Trip Reduction	Mixed-use commercial and light industrial development that includes residential units. At least 40% of floor area devoted to residential uses.	For commercial and light industrial development, a FAR of at least 2 per gross acre.	Direct, safe connections between residences and commercial/industrial uses.	Commercial uses located with minimal setbacks. Commercial includes retail and semi-retail uses.	LACMTA, 1995

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Table A-2. Transportation Impact Factors – Development Around Bus Transit Corridors

Transportation Impact Factor	Development Pattern	Density/Intensity	Pedestrian/Bicycle Facilities	Other Characteristics	Sources
[illegible]% Vehicle Trip Reduction	Locate commercial and/or light industrial uses within 1/4 mile of a bus transit corridor.	Minimum FAR of 0.75 per acre for commercial/light industrial development.	Direct, safe connections between commercial/industrial uses and transit stops. Preferable if safe and secure bicycle parking provided at commercial/industrial uses.	Commercial uses located with residential uses. Commercial includes retail and non-retail uses.	JHK, 1995; LACMTA, 1993
[illegible]% Vehicle Trip Reduction	Locate commercial and/or light industrial uses within 1/4 mile of a bus transit corridor.	Minimum FAR of 3 per acre for commercial/light industrial development.	Direct, safe connections between commercial/industrial uses and transit stops. Preferable if safe and secure bicycle parking provided at commercial/industrial uses.	Commercial uses located with residential uses. Commercial includes retail and non-retail uses.	JHK, 1995; LACMTA, 1993
[illegible]% Vehicle Trip Reduction	Locate residential development within 1/4 mile of a bus corridor.	Minimum residential density of 15 du/acre.	Direct, safe connections between residences and transit stops. Preferable if safe and secure bicycle parking also be provided at the most heavily used transit stops.		LACMTA, 1993
[illegible]% Vehicle Trip Reduction	Locate commercial and/or light industrial uses within 1/4 mile of a bus transit corridor.	Minimum FAR of 2 per acre for commercial/industrial development.	Direct, safe connections between commercial/industrial uses and transit stops. Preferable if safe and secure bicycle parking provided at commercial/industrial uses.	Commercial uses located with residential uses. Commercial includes retail and non-retail uses.	LACMTA, 1993
[illegible]% Vehicle Trip Reduction	Residential development located within 1/4 mile of a bus transit corridor. Minimum 50% of front doors designed [illegible] oriented towards [illegible].	Minimum residential density of 24 du/acre.	Direct, safe connections between commercial/industrial uses, residences, and transit stops. Preferable if safe and secure bicycle parking provided at the most heavily used transit stops.	Commercial uses should be located with adjacent residential. Commercial includes retail and non-retail uses.	LACMTA, 1993
10% Vehicle Trip Reduction	Locate mixed-use commercial/light industrial development that includes residential uses within 1/4 mile of a bus transit corridor, with at least 50% of floor area for residential use.	Minimum FAR of 2 per acre for commercial/industrial development.	Direct, safe connections between commercial/industrial uses, residences, and transit stops. Preferable if safe and secure bicycle parking provided at the most heavily used transit stops.	Commercial uses located with residential uses. Commercial includes retail and non-retail uses.	LACMTA, 1993

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Table A-3. Transportation Impact Factors – Development Around Transit Centers and Light Rail Stations

Transportation Impact Factor	Development Pattern	Density/Intensity	Pedestrian/Bicycle Facilities	Other Characteristics	Sources
5% Vehicle Trip Reduction	Locate commercial and/or light industrial uses within 1/4 mile of a transit center or light rail station.	Minimum FAR of 1 per gross acre for commercial/industrial development.	Direct, safe connections between commercial/industrial uses and transit centers/light rail stations. Pedestrian [illegible] safe and secure bicycle parking provided at commercial/industrial uses, transit centers, and light rail stations.	Commercial uses located with regional networks. Commercial, industrial and residential uses.	JHK, [illegible] LACMTA, 1992
10% Vehicle Trip Reduction	Locate residential development within 1/4 mile of a transit center or light rail station.	Minimum residential density of 24 du per gross acre.	Direct, safe connections between residential uses and transit centers and light rail stations. Sidewalks and safe and secure bicycle parking provided at transit centers and light rail stations.	Residential uses located with regional networks. Commercial, industrial and residential uses.	LACMTA, 1992
15% Vehicle Trip Reduction	Locate commercial and/or light industrial uses within 1/4 mile of a transit center or light rail station.	Minimum FAR of 1 per gross acre for commercial/industrial development.	Direct, safe connections between commercial/industrial uses and transit centers/light rail stations. Sidewalks and safe and secure bicycle parking provided at commercial/industrial uses, transit centers, and light rail stations.	Commercial uses located with regional networks. Commercial, industrial and residential uses.	LACMTA, 1992
15% Vehicle Trip Reduction	Residential or mixed-use development located within 1/4 mile of a transit center or light rail station. Minimum of 10% of floor area devoted to [illegible] uses oriented toward [illegible] residents.	Minimum residential density of 24 du per gross acre.	Direct, safe connections between commercial/industrial uses, residences, and transit centers or light rail stations. Sidewalks and safe and secure bicycle parking provided at commercial/industrial uses, transit centers, and light rail stations.	Commercial uses located with regional networks. Commercial, industrial and residential uses.	LACMTA, 1992
20% Vehicle Trip Reduction	Locate mixed-use commercial and light industrial development that includes non-residential uses within 1/4 mile of a transit center or light rail station. At least 10% of floor area for residential uses.	Minimum FAR of 2 per gross acre for commercial/industrial development.	Direct, safe connections between commercial/industrial uses, residences, and transit centers or light rail stations. Sidewalks and safe and secure bicycle parking provided at commercial/industrial uses, transit centers, and light rail stations.	Commercial uses located with regional networks. Commercial, industrial and residential uses.	LACMTA, 1992

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I. ENDNOTES

1. Institute of Transportation Engineers, *Traffic Engineering for Neo-Traditional Neighborhood Design*, February 1994.
2. Organization for Economic Cooperation and Development, *Traffic Safety of Elderly Road Users*, 1979, p. 28.
3. Organization for Economic Cooperation and Development, supra, p. 91.
4. Zegeer, Charles V., et al. *Analysis of Elderly Pedestrian Crashes and Recommended Countermeasures,* TRB 1993, paper no. 931054.
5. AASHO Committee reports and J.LSert and International Congress for Modern Architecture, *Can Our Cities Survive? an ABC of Urban Problems, Their Analysis, Their Solutions.* Cambridge, Massachusetts. The Harvard University Press, 1947.
6. Examples include Madison, Wisconsin (22', two-way, on-street parking) and San Francisco, California (21', two-way, on-street parking).
7. Kulash, Walter et al. *TND Will the Traffic Work?*
8. Institute of Transportation Engineers, *Traffic Engineering for Neo-Traditional Neighborhood Design*, February 1994, ITE Informational Report.
9. Cite University of Washington Seattle study, & Bicycle Federation of America.
10. Personal discussion with C. Chellman and said fire chief (name withheld) July 1989.
11. American Association of State Highway and Transportation Officials, *AASHTO Policy on Geometric Design of Highways and Streets*. Washington, DC. 1990, p. 108.
12. The sides of TND streets contain, by design definition: buildings, fences, walls, curbs, parked vehicles, pedestrians and other elements that are not expectedly found along highways. In addition, and also by definition, TND streets provide direct vehicular and non-vehicular access to abutting properties and this, too, is not the case for highways where the concept of a "forgiving roadside" may be both appropriate and effective.
13. These concepts begin to address the legal concepts of *tort* liability, *negligence, proximate cause* (of injuries), and *foreseeability,* all of which are jurisdiction-dependent for their legal definitions. As this is not intended to be a legal text, the practical concepts are given here. For additional and more legally oriented discussion, see, for example, *Killer Roads: From Crash to Verdict,* The Michie Company, 1986 § 6 and *Designing Safer Roads,* TRB Special Report 214, 1987.
14. AASHTO, supra, p. 108.
15. AASHTO, supra, pp. 118–119; notes that 2.5 seconds is considered an adequate reaction time for most situations, but not "the most complex conditions encountered" by drivers. For TND design, the combination of increased driver awareness, due to slower speeds and eye contact with others on the street, is felt to offset the "more complex" nature of the smaller-scale pedestrian-oriented environment; 2.5 seconds is likely conservative for most TND design situations, and where additional data or local conditions warrant consideration of a deviation in accordance with the principles stated in these guidelines, such consideration should be given based on those conditions and/or data.
16. The distance an object will slide along a surface to a stop is related to the square of the object's velocity and the friction factor that varies somewhat with speed, as is shown. The formulas relating mph speed and feet of travel are: V= 5.4772 x *square root of* f x S
    AND S= $(V^2 / (30 \times (f+G)))$ v = velocity (mph) f = coefficient of friction s = distance (ft)
17. OECD, 1979, p.4.
18. See, for example, *Making Better Places, Urban Design Now,* Butterworth Architecture, 1993, p. 123 (30 Kmh); City of Boulder Colorado Street Standards for "Access Lanes" (20 mph); *Accommodating the Pedestrian*, Richard K. Untermann, Van Nostrand Reinhold, 1984 p. 109 (20 mph); and Appleyard, Donald, *Livable Streets*, Los Angeles, CA. University of California Press, 1981, p. 251 (25 mph "too fast" and "acceptable speeds for neighborhoods with children may have to be as low as 15 mph").

19. See, for example, *Residential Streets,* ULI, et al. 1981, p. 36 (implied with "questionable" need for design speed on residential streets that "tend toward low vehicle speeds"); *Traffic Calming Policy,* City of Toronto, 1994, p. 6 (30 Kmh); *Traffic Calming Guidelines,* Devon County Council, 1991, p. 12 (20 mph & "sub-20 mph").
20. Proposed Model and Development Standards and Accompanying Model State Enabling Legislation 1993 Edition, Instrument Number DU100K000005897, p. 11.
21. The abbreviated injury scale, or AIS, a measure of an expected or sustained injury is related to speed as follows: $AIS = 0.0044 \times (Vc)^2$ where Vc is impact speed in mph (from Limpert, p. 663).
22. This relationship is: $AIS_2 = 0.9 + 0.008\ (Vc)^2$ (from Limpert, p. 664).
23. Limpert, Rudolph, *Motor Vehicle Accident Reconstruction and Cause Analysis.* Fourth Edition. Charlottesville, Virginia, The Michie Company, 1994, p. 663.
24. Homburger, Wolfgang S., Elizabeth A. Deakin, Peter C. Bosselmann, Daniel T. Smith, and Bert Beukers, *Residential Street Design and Traffic Control,* Institute of Transportation Engineers, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1989, p. 64.
25. Following the destruction of large sections of Southern Florida in the wake of Hurricane Andrew, many designers attempted to assist with the re-platting of inefficiently laid out neighborhoods, but found their efforts frustrated by the original platting and divisions of these neighborhoods. Without a massive condemnation and public taking of all of the properties, which was not funded, no effective re-platting of many neighborhoods could be effected.
26. Appleyard, Donald, *Livable Streets,* Los Angeles, CA. University of California Press, 1981, p. 41.
27. Jacobs, Allan B, *Great Streets,* Cambridge, MA. Massachusetts Institute of Technology, 1993, p. 306.
28. Transportation Research Board, *Highway Capacity Manual,* pp. 1–3.
29. Ibid.
30. Personal observation and measurement, C.E. Chellman and personal discussion between C.E. Chellman and San Francisco Dept. of Traffic, July 29, 1993; see also Report on New Standards for Residential Streets, Portland, Oregon, August 1, 1994, p. 4.
31. See: Untermann, Richard K., *Accommodating the Pedestrian, Adapting Towns and Neighborhoods for Walking and Bicycling,* p. 111; also trip generation and streets study of Portsmouth, NH by White Mt. Survey Co., Inc. not yet published.
32. Bray, Terrence L. and Karen Carlson Rabiner, *Report on New Standards for Residential Streets in Portland, Oregon.* City of Portland, Oregon: Office of Transportation, August 1, 1994.
33. AASHTO, supra, pp. 151& 188, the formula (feet) is:

R = centerline radius (ft)	V = velocity (mph)	$R_{min} = \dfrac{V^2}{15 \times (e + f)}$
f = coefficient of friction	e = superelevation	

34. AASHTO, supra, pp. 98–99.
35. Jacobs, Allan B, supra pp. 272–273.
36. C.E. Chellman, personal design experience with site designs for post-acute trauma facilities throughout the U.S.
37. Jacobs, Allan B, supra p. 273.
38. National Research Council, *Highway Capacity Manual*, TRB, pp. 13–9. At LOS E, "virtually all" pedestrians' walking gaits are restricted by volumes and at LOS F, all are "severely restricted." Perhaps on well-designed streets, higher pedestrian volumes are less problematic to pedestrians.
39. Jacobs, Allan B., supra, p. 273.
40. Discussions with Michael J. Monahan, Assistant Director of Public Works, Minneapolis, Minnesota, December 1995.
41. *Facts About Bicycling,* Bicycle Federation of America, April 1994.
42. Bicycle Institute of America, 1992, as reported by The Bicycle Federation of America, April, 1994; see also *The National Bicycling and Walking Study*, Final Report, p. 10, U.S. Dept. of Transportation, Federal Highway Administration, Publication # FHWA-PD-94-023 (54 percent adult drivers in 1991).

43. *Pathways for People,* Harris Polls, 1992.
44. U.S. Dept. of Transportation, National Bicycling and Walking Study, Case Study No 1, "*Reasons Why Bicycling and Walking Are Not Being Used More Extensively as Travel Modes,*" 1993, p. 17.
45. See also, *The National Bicycling and Walking Study*, ibid.
46. Stone, John and Rhett Fussell, *Overview of Trip Generation: A Practitioner's Guide.* Transportation Planning Committee, Urban Transportation Division ASCE, Draft, June 1994, p. 3.
47. Institute of Transportation Engineers, *Trip Generation* , Washington, DC, 1985.
48. Accessibility Measure and Transportation Impact Factor Study, ODOT/DLCD TGM Program, Draft Report, JHK & Assoc., Pacific Rim Resources and SG Associates, August 11, 1995.
49. See also: *National Bicycling and Walking Study, Final Report,* U.S. Dept. of Transportation, 1993, pp. 11 & 12.
50. Jacobs, Allan B., supra, p. 313.

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(Please note that the following references vary widely in significance, but all are of interest to practitioners involved in TND street design.)

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